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DEVELOPMENT OF AN EFFECTIVENESS MODEL OR METRIC FOR THE AIR FORCE ENVIRONMENTAL COMPLIANCE ASSESSMENT AND MANAGEMENT PROGRAM (ECAMP)

THESIS

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THESIS

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List of Acronyms

ACC	Air Combat Command
AF	Air Force
AFB	Air Force Base
AFCEMET	Air Force Civil Engineering Management Engineering Team
AFLC(s)	Air Force Logistics Center(s)
AFMC	Air Force Materiel Command
AFMD	Air Force Manpower Determinant
AFSCs	Air Force Specialty Codes
AFSC	Air Force Systems Command
AFR	Air Force Regulation
AMC	Air Mobility Command
BEE	Bioenvironmental Engineering
DoD	Department of Defense
ECAMP	Environmental Compliance Assessment and Management Program
EM	Environmental Management
EPC	Environmental Protection Committee
EQPMs	Environmental Quality Performance Measures
FAC	Functional Account Code
FFCA	Federal Facilities Compliance Act
MAJCOM	Major Command
NOV(s)	Notice(s) Of Violation
RCO	Regional Compliance Office

Abstract

The Department of Defense (DoD) and the Air Force (AF) are committed to being national leaders in protecting and enhancing the environment and achieving environmental compliance (38:v; 39). This commitment is exemplified by the Air Force Chief of Staff's goal of "no notices of violation (NOVs)" (36). However, the number of AF NOVs from 1990-1992 rose from 103 to 178 an increase of 73 percent (7; 13; 25). A July 1992 AF Inspector General Report also concluded that ECAMP findings were not being fully utilized and that "several commands were not effectively using external Environmental Compliance Assessment and Management Program (ECAMP) reports to direct corrective actions or allocate resources" (4:6).

To aid AF leaders in solving these problems, and protecting and enhancing the environment, this research developed a methodology to standardize and use ECAMP findings, along with historical NOV data, to assist decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance. The ECAMP Effectiveness Model developed in this research provides a quick and easy, visual indication of an installation's relative ECAMP effectiveness. The research indicates that the proposed model is extremely flexible; it can be easily

adjusted to reflect changing AF or command goals or averages; it can be used both retrospectively and prospectively with either standardized and/or unstandardized ECAMP findings; and it uses manpower, NOV, and ECAMP report data that is readily available to decision-makers. Based on these research findings, it was recommended that Air Staff and Major Command (MAJCOM) environmental leaders review the research results and adopt the proposed ECAMP Effectiveness Model as an AF metric to measure ECAMP effectiveness.

DEVELOPMENT OF AN EFFECTIVENESS MODEL OR METRIC FOR THE AIR FORCE ENVIRONMENTAL COMPLIANCE ASSESSMENT AND MANAGEMENT PROGRAM (ECAMP)

I. Introduction

General Issue

The Department of Defense (DoD) and Air Force (AF) are committed to being national leaders in protecting and enhancing the environment and achieving environmental compliance (38:v; 39:1). The challenge facing DoD and the AF is to achieve compliance with the multitude of dynamic and complex environmental laws and regulations in the face of shrinking budgets and force reductions (28:243). Although DoD and the AF have been working diligently to meet this challenge, a recent study by Salthouse, Brown, and Oh indicates that the number of notices of violation (NOVs) issued to DoD by federal, state and local regulators increased from approximately 140 in FY83 to 626 in FY89 (38:1-1). In addition, the AF currently has over 180 open enforcement items (12). To reverse this trend, a method is needed to identify installations with potential environmental compliance problems. By developing such a method, scarce resources can be properly allocated to prevent compliance problems and protect and enhance the environment.

Environmental Auditing

One of the most common means of preventing compliance problems is proactive environmental auditing (22:1706). Many businesses, such as Du Pont, have been performing environmental audits since the 1970s, but environmental auditing really gained impetus after the Environmental Protection Agency (EPA) established a formal policy in 1986 (35:72). This policy encourages regulated entities to develop, implement, and upgrade environmental auditing programs (24:25004). More specifically, the EPA policy formally endorses environmental auditing at federal facilities (24:25004).

As defined in the EPA policy statement, an environmental audit is:

> A systematic, documented, periodic and objective review by regulated entities of facility operations and practices related to meeting environmental requirements. (24:25006)

The primary objective of environmental audits is to assess and improve environmental compliance (35:72). In 1988 the AF implemented the EPA policy, by initiating the AF Environmental Compliance Assessment and Management Program (ECAMP). Another key reason for implementing ECAMP was to curb the increasing number of regulatory NOVs by using proactive environmental leadership techniques(40:1).

ECAMP

ECAMP is a comprehensive self-evaluation and program management system that is designed to achieve, maintain, and monitor environmental compliance at all AF installations (18:1; 40:1). ECAMP utilizes internal and external environmental compliance evaluations or audits and management action plans to accomplish these goals (18:1). Internal evaluations are performed by installation personnel under the direction of the local Environmental Protection Committee (EPC), and external audits are conducted by contractors or Major Command (MAJCOM) personnel not directly associated with the evaluated activities (18:5). Internal evaluations are required annually, and an external audit must be accomplished at least once every three years (18:3,5).

The major ECAMP objectives as stated in AF Regulation 19-16 are to:

a. Improve AF environmental management worldwide.

b. Improve AF environmental compliance and compliance management in the U.S. and Possessions.

c. Build supporting financial programs and budgets for environmental compliance requirements.

d. Ensure that MAJCOMs, installation commanders, environmental protection committees, environmental coordinators, bioenvironmental engineers, and natural resource managers environmental programs are effectively addressing environmental problems.

e. Anticipate and prevent future environmental problems. (18:3)

The AF has been using ECAMP evaluations in an attempt to achieve these objectives since 1988; however, despite diligent efforts, the number of NOVs issued remains far above the Air Force Chief of Staff's goal of "no notices of violation" (36). Figure 1 illustrates the number of AF NOVs from 1990 - 1992. As the chart clearly shows, five years after the inception of ECAMP, NOVs continue to rise.

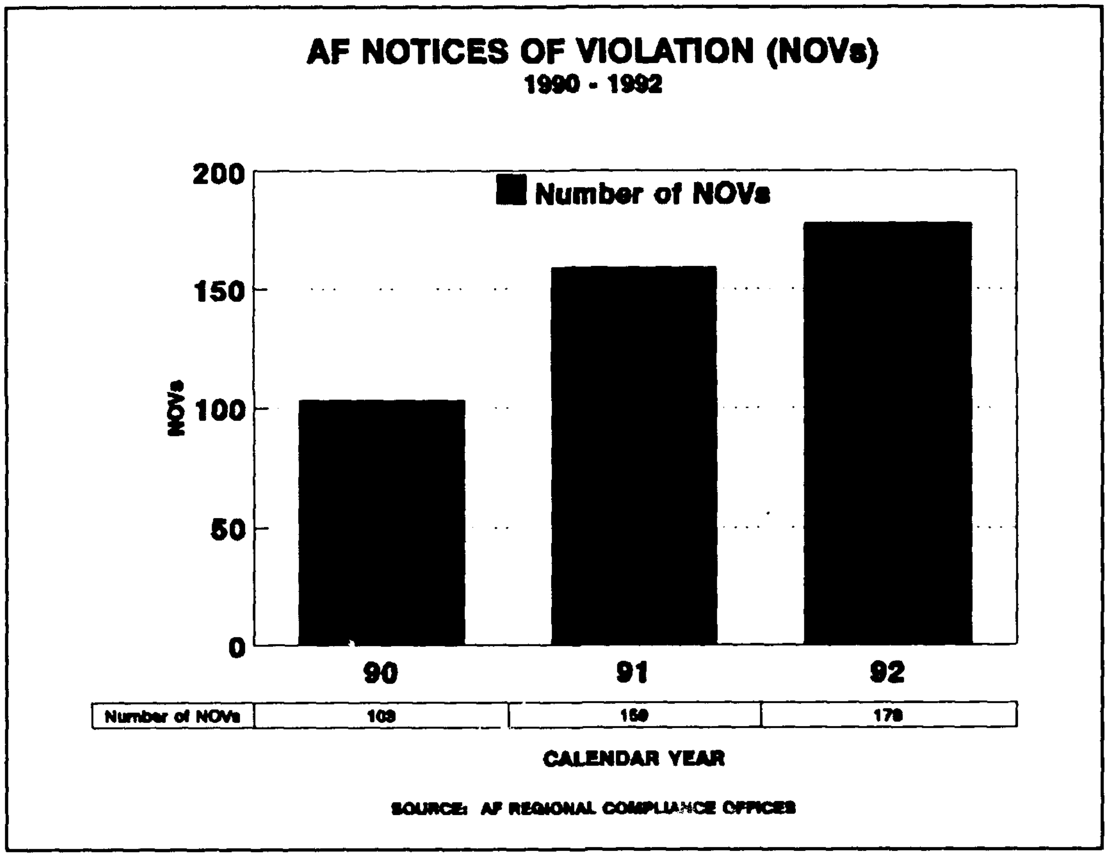

Figure 1. AF Notices of Violation, 1990 -1992 (7; 13; 25)

In fact, the number of NOVs over this two year period actually increased by 73 percent from 103 to 178. Although this increase could be due in-part to the increasing number, complexity, and enforcement of environmental regulations, it clearly depicts the degree of effort necessary to achieve the Chief of Staff's NOV goal.

In order to attain this goal, the AF must find a better method to use ECAMP findings to anticipate and prevent future environmental problems thereby reducing NOVs. A July 1992 AF Inspector General Report concluded that ECAMP findings were not being fully utilized and that "several commands were not effectively using the external ECAMP reports to direct corrective actions or allocate resources" (4:6). Ideally, Air Staff and MAJCOM program managers should be able to compare the number and type of ECAMP findings from various installations and identify the installations that require resources to prevent future NOVs and improve environmental compliance (38:3-7).

In reality, these decisions are confounded and made difficult because bases vary significantly by size and mission, with larger installations tending to have more ECAMP findings and NOVs than smaller installations (38:3-7). For example, how can a decision-maker compare the number of ECAMP findings and NOVs between a large maintenance depot and a much smaller installation with mobility aircraft and missiles? To account for these differences, ECAMP findings should be standardized or weighted to allow unbiased comparisons between dissimilar organizations (38:3-7). Standardizing or weighting is accomplished by adjusting the value to be standardized by an unbiased weighting factor that accounts for the variabilities between installations. If an unbiased standardizing factor can be established, ECAMP findings could be standardized, and a methodology that uses standardized ECAMP findings to identify installations with a high probability of future compliance problems could be developed. Ultimately, this methodology would allow Air Staff and MAJCOM decision-makers to compare the number and type of ECAMP findings from various bases to identify installations where resources can best be directed to prevent NOVs.

Research Problem

To attain the Chief of Staff's goal of "no notices of violation" (36) and ensure that scarce resources are properly allocated to protect and enhance the environment, the AF needs a methodology to standardize and use ECAMP findings, along with historical NOV data, to assist AF decision-makers in identifying the installations that require resources to prevent future environmental problems and improve environmental compliance.

Research Objectives

The purpose of this research was to develop, test, evaluate, and revise a methodology that standardizes ECAMP findings and uses this information, along with historical NOV data, to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance. Specific research objectives were to:

1. Demonstrate that environmentally-related manpower determinants can be used to standardize ECAMP findings thereby enabling unbiased comparisons between dissimilar AF installations.

2. Develop a methodology that uses the standardized ECAMP findings and historical NOV data to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance.

3. Test, evaluate, and revise the methodology for possible use throughout the AF.

Scope

The focus of this research will be to develop, test, evaluate, and refine a methodology that standardizes and uses ECAMP findings and historical NOV data to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance. Four existing environmentally-related AF manpower determinants will be objectively evaluated for use as standardizing factors, and the factor that best allows unbiased comparisons of ECAMP findings will be selected. Existing ECAMP findings will then be standardized and used with historical NOV data to develop a methodology that assists AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance for representative AF bases within Air Force Materiel, Air Mobility, and Air Combat Commands. Historical ECAMP findings will be obtained from the respective MAJCOMs, and historical NOV data will be provided by the AF Regional Compliance Offices. Only external ECAMP findings will be used as these are the only audits that are readily available and external evaluations are generally believed to be unbiased.

Limitations

Data availability limits this research in two ways. First, the number of external ECAMP evaluations will be limited as external audits are only performed every three years. Since ECAMP was originally implemented in 1988, every installation should have had at least one external evaluation to date. However, this ECAMP data must be comparable to the NOV data. The amount of NOV data that is available for comparison is limited to the data in the AF Regional Compliance Offices' data bases which were initiated in early 1990. The effect of the limits on these two data sets will be to restrict the time-frame of the study; however, this restriction is also advantageous in that these data sets represent the most current regulatory period and emphasis. Overall, the advantages of using current ECAMP and NOV data may out-weigh the data availability limitations.

Operational Definition of NOV

For this research, a Notice of Violation (NOV) is defined as a violation of environmental laws or regulations resulting in enforcement actions by the EPA, state or local regulators and an entry into the environmental compliance data bases maintained by the Regional Compliance Offices (RCOs) (38:2-2). This operational definition essentially makes NOVs equivalent to enforcement actions by applying the common and frequently misused NOV terminology. The reader should understand that although all NOVs are enforcement actions, not all enforcement actions are NOVs

Definitions

The definitions provided below are routinely used in ECAMP, and they have been extracted from AF Regulation 19-16, "Environmental Compliance Assessment and Management Program" (18:5,6).

Environmental Protocol. The plan and procedures which are to be followed in conducting an evaluation of specific media (air, water, hazardous waste. etc.)

External Evaluation. A single- or multi- media evaluations conducted by personnel not directly associated with the evaluated activities.

Internal Evaluation. A single- or multi-media assessment conducted by installation personnel under the auspices of the EPC.

Major Finding. A problem categorized as major requires action, but not necessarily immediately.

Minor Finding. Minor findings are mostly administrative in nature.

Multi-Media Evaluation. The evaluation of two or more assessment protocols.

Significant Finding. A problem categorized as significant requires immediate action

Thesis Organization

Chapter II of this study presents a review of the literature related to environmental auditing, ECAMP, measuring environmental compliance, and federal facility compliance. Special emphasis is also placed on reviewing the logic behind using standardized findings, briefly discussing the absence of comparable research, and describing the development of four environmentally-related manpower determinants. Finally, the chapter findings are summarized, and conclusions are drawn based on the literature review.

Chapter III describes the research approach used to develop, test, evaluate, and revise a methodology to use standardized ECAMP findings and historical NOV data to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance. The chapter begins by reviewing the research objectives, and providing an overview of the data collection activities and concludes by describing the general methods used to achieve the specific research objectives.

Detailed research results and data analyses are presented for the manpower data analysis, pilot study, expanded study, and proposed ECAMP Effectiveness Model in Chapter IV. Specifically, this chapter provides background information, discusses and describes the study results, and summarizes overall research results for each of these four major chapter headings.

Finally, Chapter V reviews the research problem and objectives, summarizes and describes how the research results achieved the three research objectives, concludes that the ECAMP Effectiveness Model developed in this research provides a quick and easy, visual indication of an installation's relative ECAMP effectiveness, and recommends that AF and MAJCOM environmental leaders review the research results and adopt the proposed ECAMP Effectiveness Model as a metric to measure ECAMP effectiveness.

II. Literature Review

Overview

This literature review serves two distinct purposes. First to review, describe, and summarize the environmental auditing and ECAMP literature related to using standardized external ECAMP findings to anticipate and prevent future environmental compliance problems. Second, to demonstrate that environmentally-related manpower determinants are indicative of installation specific environmental compliance requirements. Thus, it should be possible to standardize ECAMP findings using installation specific environmentally-related manpower authorizations thereby enabling unbiased comparisons of ECAMP findings from dissimilar AF bases.

The information is organized into nine major sections with several sub-sections. The review begins by discussing various definitions, essential characteristics, and current trends in environmental auditing. Then it summarizes relevant information on ECAMP implementation, external evaluations, and ECAMP findings. The third section reviews EPA guidance on measuring environmental compliance, outlines the difficulties associated with measuring audit program effectiveness, and discusses existing ECAMP metrics. Section four provides background information on federal facility compliance and describes the potential financial impacts of the Federal Facility Compliance Act. Next, the absence of comparable research is briefly discussed, and then section six reviews the background information on, and develops the logic behind, using standardized ECAMP findings. Section seven comprises the longest portion of the chapter providing a detailed review of the four environmentally-related manpower determinants that were considered as standardizing factors. The final two sections summarize the findings and draw conclusions based on the literature review.

Environmental Auditing

This section discusses various definitions, essential characteristics, and current trends in environmental auditing. Overall, any methodology or model that can improve environmental audit effectiveness could expand the generally accepted characteristics for effective environmental audits and start a new trend in environmental auditing.

Definitions. As stated in Chapter I, the EPA defines environmental auditing as "a systematic, documented, periodic and objective review by regulated entities of facility operations and practices related to meeting environmental requirements" (24:25004). Greeno et al define environmental auditing as:

> . . . the process of determining whether all or selected levels of an organization are in compliance with regulatory requirements and internal policies and standards. (27:3)

Numerous other definitions also exist and an ECAMP training manual developed for the AF by Arthur D. Little INC. lists seven (6:1-3,1-4). In addition to being defined in various ways, other terms frequently used to describe the environmental auditing process include environmental surveillance, environmental review, environmental survey, environmental appraisal, environmental evaluation, environmental quality control, and environmental assessment (22:1706; 34:18).

Regardless of the definitions or terms used to describe the environmental auditing process, effective environmental auditing programs generally include the seven key elements discussed in the <u>EPA Environmental Auditing Policy Statement</u>. These elements include:

I. Explicit top management support for environmental auditing and commitment to follow-up on audit findings.

II. An environmental auditing function independent of audited activities.

III. Adequate team staffing and auditor training.

IV. Explicit audit program objectives, scope, resources, and frequency.

V. A process which collects, analyzes, interprets and documents information sufficient to achieve audit objectives.

VI. A process which includes specific procedures to promptly prepare candid, clear and appropriate written reports on audit findings, corrective actions, and schedules for implementation.

VII. A process which includes quality assurance procedures to assure the accuracy and thoroughness of environmental audits. (24:25009)

Although the EPA published these elements over six years ago, the current literature supports their validity. Hunt lists nine elements of an effective environmental audit program all of which can be found within the EPA's list (31:74). Similarly, Lear performed an extensive literature review, identifying nine essential characteristics for an effective environmental auditing program and concluding that the seven EPA elements included all of the nine characteristics identified in the review (34:38,39). Lear's essential characteristics are listed in Table 1.

TABLE 1

ESSENTIAL CHARACTERISTICS FOR AN EFFECTIVE ENVIRONMENTAL AUDITING PLAN

1. Top Management Support
2. Commitment to Follow-up on Findings
3. Independent Auditors
4. Adequate Staffing and Training of Auditors
5. Establishment of Clear and Specific Program Objectives
6. Clearly Defined Procedures
7. Written Audit Reports
8. Clearly Identified Corrective Actions
9. Quality Assurance Procedures

(34:39)

The similarities between the two lists are obvious. However, the lists seem to indicate that top management has adequate financial resources to fund all environmental compliance requirements identified. In cases where requirements exceed resource availability, such as within the AF, managers need a method of using existing audit findings and historical noncompliance data to assist in ensuring that scarce resources are properly allocated and apportioned among all competing environmental compliance requirements.

The focus of this research is to develop a method to use standardized external ECAMP findings and historical NOV data to assist AF leaders with these important resource allocation decisions. If successful, this research will aid decision-makers in improving the overall effectiveness and usefulness of ECAMP thereby assisting the AF in becoming a national leader in protecting and enhancing the environment. Essentially, this research parallels the fifth major ECAMP objective which is to "anticipate and prevent future environmental problems" (18:3). In general, any model or methodology that can improve environmental audit effectiveness could expand, and possibly complete, the lists of essential characteristics for effective environmental audits and start a new trend in environmental auditing.

Trends. Although environmental auditing is a relatively new and evolving discipline, its origin dates back to the 1970s when a handful of companies developed environmental auditing systems as internal management tools to review and evaluate their own environmental programs (27:vii). In the United States, environmental audits are not required by law; however, the EPA has formally endorsed auditing since 1986, and many Fortune 500 companies have been routinely performing environmental audits since the early 1980s (11:2). Moreover, current trends indicate that corporate stockholders, regulators, and the public at large now expect routine environmental audits by independent sources (11:2,3). These new expectations are compelling companies to focus more on the underlying causes of noncompliance such as training, staffing, resource allocation, and communications rather than on superficial considerations such as how many hazardous waste drums were improperly labelled (11:4-7). The increased emphasis on, and visibility of, these audits is causing many companies to focus not only on the compliance issues but on the environmental management systems as well (11:4).

Downs describes three special-focus audits (1) environmental compliance audits that use internal or external evaluations to assess and report overall company compliance; (2) environmental management assessments that use independent auditors to evaluate a company's environmental compliance policies, practices, and controls; and (3) criminal liability audits to assess individual and corporate potential criminal liabilities (21:59-60). Downs further emphasizes that:

> It is no longer sufficient for an environmental management system to identify compliance problems or even respond to specific environmental concerns. To be effective in the 1990s, a management system must enhance the corporation's long-term ability to:
>
> - Assign responsibility and assure accountability for environmental performance;
> - Identify and assess existing and potential compliance, failures, management system weaknesses, and areas of potential vulnerability;
> - Communicate such information to people who need to know; and
> - Foster corrective action by those responsible for responding to and managing those problems. (21:60)

In essence, the new environmental auditing focus on management parallels the objectives of this thesis in that they both seek to use the audit results to assist management in anticipating and preventing future environmental compliance problems.

ECAMP

This section provides relevant background information on ECAMP establishment and implementation, external evaluations, and findings. In general, this section demonstrates the significant resource demand that the environmental compliance requirements identified by ECAMP findings can create. Overall, ECAMP findings can and do play an important role in AF and installation resource allocation decisions.

Background. In June 1988, the Air Force Office of the Chief of Staff established and implemented ECAMP in response to reports from the Government Accounting Office, DoD Inspector General, AF Audit Agency and the AF Scientific Advisory Board that identified serious environmental compliance deficiencies at AF facilities (40:1). As described in the implementation policy, the primary objective of ECAMP is to:

> . . . establish the use of environmental compliance evaluations to evaluate Air Force compliance with all applicable, Federal, state, local, DoD, and USAF environmental laws and regulations. (40:2)

Overall, the program is designed to "resolve minor deficiencies through procedural changes, education, and training, and devote additional resources to alleviate major compliance deficiencies" (45:1). Similarly, the intent of this research is to use standardized external ECAMP findings and historical NOV data to anticipate compliance problems so that additional resources can be directed to prevent these major compliance deficiencies.

External ECAMP Evaluations. As discussed in Chapter I, external ECAMP evaluations must be conducted at least once every three years by personnel not directly associated with the installation (18:3). As a comprehensive evaluation, ECAMP considers any applicable protocol from the ten ECAMP protocols described in Table 2. Each protocol identifies key federal legislative requirements, typical state and local regulations, and DoD and AF specific requirements (5:1).

TABLE 2

ECAMP PROTOCOLS

Air Emissions	Pesticide Management
Hazardous Materials Management	POL Management
Hazardous Waste Management	Solid Waste Management
Natural and Cultural Resources	Special Programs
Noise Management	Water Quality Management
	(45:4)

Although these protocols provide the foundation for the audit, an AF ECAMP training manual developed by Arthur D. Little Inc. further delineates the overall process into three distinct sets of activities; (1) pre-assessment activities such as scheduling, completing pre-visit questionnaires, and reviewing state and local regulations; (2) on-site activities like examining records, preforming inspections, and conducting personnel interviews; and (3) post-assessment activities such as preparing reports and conducting follow-ups (6:2-2; 45:3). Similarly, the ECAMP Training Manual describes the external ECAMP evaluation as a nine step process as shown in Table 3 (45:18).

TABLE 3

EXTERNAL ECAMP EVALUATION PROCESS

1. Pre-Evaluation Activities
2. On-Site Evaluation
3. Outbrief and Preliminary Environmental Findings
4. Preliminary Environmental Findings Review
5. Candidate Environmental Findings
6. Proposed Action Plan and Comments on the Candidate Environmental Findings
7. Draft Final Environmental Evaluations Report
8. Final Environmental Evaluation Report
9. Follow-up

(45:D-18)

For purposes of this research, the important output of the external ECAMP evaluation process is the external ECAMP Final Environmental Evaluation Report and the subsequent findings, or inspection write-ups, detailed therein.

Findings. ECAMP findings are classified as significant, major, or minor using the definitions provided in Chapter I. In general, "significant" findings pose immediate health or safety dangers and require a prompt response; "major" findings could result in NOVs, but immediate action is not necessary to prevent health or safety risks; and "minor" findings are generally administrative in nature and are not as time sensitive (5:2).

Overall, significant, major, and minor ECAMP findings can and do play an important role in AF and installation resource allocation decisions. For instance, a 1991 ECAMP evaluation at Tinker AFB identified 144 total findings (16:80). Within a few months, Tinker officials had closed 130 of the findings at a cost of $1,253,000 and programmed corrective actions to close the other 14 findings at an estimated cost of $800,000 (16:80). For this one example, simple division yields a closure cost of over $14,250 per ECAMP finding.

The total yearly AF expenditure to close-out ECAMP findings is not available. However, during a telephone interview with the Director of Engineering and Services, ECAMP Section, Headquarters USAF, Lear learned that the ECAMP process identified approximately 3,000 findings per year in 1990 and 1991 (34:3). Combining the Tinker cost figures and the Lear ECAMP findings estimate results in an total cost of approximately $42 million per year to close-out the ECAMP findings in 1990 and 1991. Although this is obviously a very rough estimate, it clearly demonstrates the significant resource demand that the environmental compliance requirements identified by ECAMP findings can create.

Measuring Environmental Compliance

This section reviews EPA guidance on measuring environmental compliance, outlines the difficulties associated with measuring audit program effectiveness, and discusses existing ECAMP metrics. Ultimately, this section establishes the importance of measuring ECAMP effectiveness and the need for an improved metric or new methodology to quantify the relationship between environmental compliance and environmental audit or ECAMP findings as suggested by the EPA.

EPA Guidance. To ensure that resources are properly allocated and apportioned among competing environmental compliance requirements, such as equipment maintenance, major construction, training, or improved administrative procedures, decision-makers need meaningful environmental compliance measures (38:v). The 1989 EPA Publication, Environmental Audit Program Design Guidelines for Federal Facilities, acknowledges the difficulties associated with measuring audit results yet stresses that some attempt to measure results should be part of all audit programs (23:50). The EPA further suggests using the number and magnitude of environmental problems identified during audits to evaluate overall program success (23:50). Specifically, the EPA guidance discusses evaluating average facility compliance rates, the number of regulatory compliance deficiencies, and environmental compliance rates based on environmental media and assigned priorities (23:5). Overall, the EPA indicates that:

> A successful environmental auditing program should be reflected in increased regulatory compliance rates on a Federal agency-wide basis . . . While no one measure or report may be solely attributable to the audit program, there still should be a direct relationship between an environmental management program's success or failure and the effectiveness of the audit program. (23:50)

This research will apply the EPA's guidance by comparing and analyzing the standardized number of audit findings per installation to the number of regulatory compliance deficiencies at the same installations over time. Ultimately, this research will quantify the direct relationship between environmental compliance and audit program or ECAMP effectiveness.

Measuring Effectiveness. Cahill and Kane indicate that environmental auditing programs are frequently implemented without considering how to measure program effectiveness (10:VIII-6). Although difficult, measuring auditing program effectiveness is critical to ensuring environmental compliance. Moreover, truly effective auditing programs typically have evaluation and analysis techniques that use the reduction in compliance problems over time as a measure of success (10:VIII-6). As discussed in Chapter I, the number of AF NOVs increased from 103 in 1990 to 178 in 1992; thus, from a purely theoretical reduction in compliance problem perspective, the ECAMP effectiveness decreased by 73 percent from 1990 to 1992 (7; 13; 25).

Since the organization and its executives can be held liable when audits identify compliance violations and formal plans are not made to correct the problems, corporate and personal liability considerations now mandate that effective audit programs contain procedures that assure corrective-action plans are in-place and functioning (10:IV-29,30).

Therefore, effective audit programs must include systematic procedures to assure senior management that where violations have been noted, actions are being taken to achieve compliance (10:IV-30). Similarly, Air Force Regulation (AFR) 19-16, formally establishes procedures to assure senior AF leadership that where ECAMP findings have been identified, formal management action plans are developed, and the appropriate actions are taken to correct the problems (18:7).

ECAMP Metrics. In accordance with AFR 19-16, each Major Command is responsible for ensuring effective ECAMP implementation (18:7). As such, each MAJCOM is free to develop its own ECAMP effectiveness measures or metrics. For example, Air Combat Command (ACC) has developed three ECAMP Environmental Quality Performance Measures (EQPMs) to:

(1) Determine how well bases close findings;
(2) Examine environmental processes for resolving deficiencies; and
(3) Establish relationships between closure rates and resource availability. (9)

Figure 2 illustrates how HQ ACC is tracking ECAMP finding close out rates.

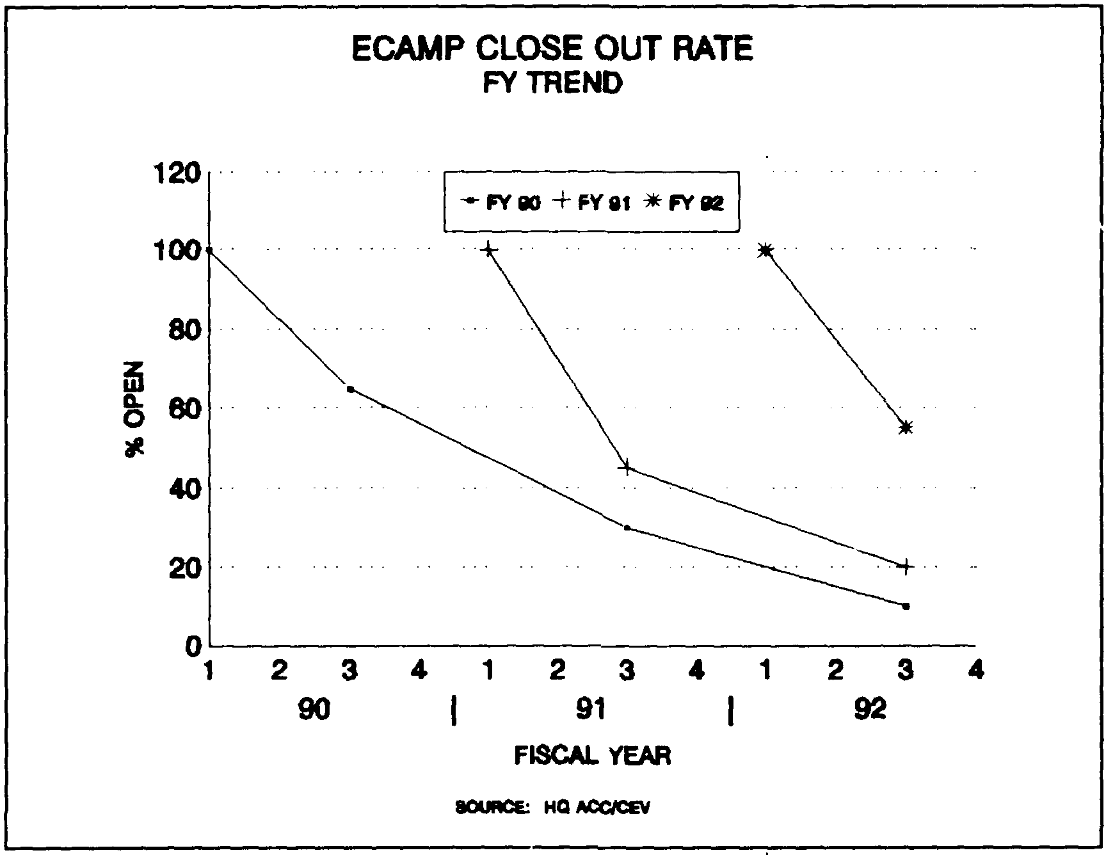

Figure 2. Sample HQ ACC ECAMP Metric (9)

As the figure indicates, the primary emphasis in ACC is on quick resolution of ECAMP findings.

Similarly, HQ AFMC has established an ECAMP metric which measures ECAMP finding closure rates at 90 and 180 days and compares these values to the command goals of 65 and 100% closure respectively (29). These metrics effectively assure senior leadership that appropriate action-plans are developed and implemented to correct ECAMP findings. However, these metrics do not measure the relationship between the AF environmental management program's success or failure, environmental compliance as measured by NOVs received, and the overall effectiveness of ECAMP at either the command or installation level. In general, the present metrics measure ECAMP effectiveness within ECAMP while a true metric should measure improved environmental performance external to ECAMP. This research develops such a true metric to quantify the relationship between environmental performance and ECAMP findings as suggested by the EPA.

Federal Facility Compliance

This section provides background information on federal facilities compliance, and it discusses the potential financial impacts of the Federal Facilities Compliance Act (FFCA). Overall, this section establishes that the potential savings in fines and penalties that could be realized from this research are extensive.

Background. The ability to quantify the relationship between ECAMP findings and environmental compliance and anticipate and prevent compliance problems will increase in importance as more environmental legislation is enacted. Hourcle cites congressional testimony by EPA officials which indicates that "63 percent of federal facilities had one or more Class I violations, compared to 38 percent in the private sector" (30:376). In response to lower compliance rates for federal facilities and to avoid a perceived double standard of weaker EPA enforcement of environmental laws against federal facilities, Congress overwhelmingly passed the Federal Facilities Compliance Act of 1992 (30:359,372).

Federal Facilities Compliance Act (FFCA). The FFCA emphasizes the importance of AF environmental compliance by requiring annual EPA inspections of all federal facilities including AF installations at agency expense, waiving federal sovereign immunity under the Resource Conservation and Recovery Act, and allowing regulators to assess fines and penalties against the AF for violating Federal, state or local solid and hazardous waste laws (43:1). In his article, "EPA's Federal Facility Program - An Insider's Perspective," Woolford indicates that:

> The protection of public health and the environment at federal facilities is a high priority for the administration, federal agencies, Congress and the states. EPA's federal facility program views itself as the steward for the public to ensure that other federal agencies comply with federal environmental statutes, rules, and regulations to the same extent as required by the private sector. (50:383)

Ultimately, this means that the AF and other federal agencies can expect fines for future noncompliance with EPA enforced federal environmental regulations. The maximum fine for noncompliance is $25,000 per day per violation, and past EPA estimates advising individual bases receiving NOVs on what fines would have been in the absence of sovereign immunity have exceeded $250,000 (43:1). Thus, when the total number of AF installations is considered, the potential impact on the AF is immense (43:1). Similarly, the potential savings in fines and penalties that could be realized by developing a methodology or model to use standardized ECAMP findings and historical NOV data to assist AF decision-makers in determining relative ECAMP effectiveness and improving environmental compliance as done in this research are also extensive.

Comparable Research

Although the potential benefits of using past environmental audit findings and NOV data to assist decision-makers in identifying the areas that require resources to prevent future environmental problems and improve environmental compliance are immense, this literature review did not reveal any existing research in this area. The absence of comparable research was not unexpected since environmental auditing is a relatively new and evolving discipline, and the use of these data sources has not yet developed (27:vii). Furthermore, the inherent difficulties associated with assessing audit results, such as selecting accurate metrics and comparing findings from dissimilar facilities, make predicting future compliance complex (23:50). Conversely, to reverse the trend of increasing NOVs within the AF, a method is needed to use historical ECAMP findings to assist decision-makers in anticipating and preventing future environmental problems thereby reducing NOVs. As suggested by Salthouse, Brown, and Oh, the first step in comparing environmental compliance audits is developing a standardization method that allows unbiased comparisons of installations with dissimilar environmental compliance requirements (38:3-7).

Finding Standardization

This section reviews background information on, and develops the logic behind, developing a finding standardization method. Finally, the section concludes that standardizing ECAMP findings using environmentally-related manpower determinants should allow Air Staff and MAJCOM program managers to compare ECAMP findings from dissimilar AF installations.

Background. To improve efficiency of resource allocation which will in-turn prevent noncompliance problems, Air Staff and MAJCOM decision makers must be able to compare and use ECAMP findings from various installations to identify base specific projects that require resources to prevent future NOVs. However, comparing findings from various size installations with different missions in separate regions over time is difficult at best. Salthouse, Brown and Oh recommend measuring compliance by using normalized measures "such as violations per source that allow unbiased comparisons between dissimilar groups or organizations" (38:3-7). Similarly, this research uses existing AF manpower determinants to weight or standardize the total number of ECAMP findings thereby enabling unbiased comparisons between dissimilar installations. Standardizing or weighting is accomplished by adjusting the value to be standardized, by the standardizing factor.

Logic. As described in the AF Engineering Service Center booklet, Manpower Management, the logic behind manpower determinant development is that a required mission task demands a manpower position, and the basis for all manpower positions originates in the work requirements (3:5-5). Since installations typically vary in size and/or mission, installation size, mission, and local regulatory climate will ultimately dictate the various environmental compliance requirements for the different installations.

Applying similar logic, the environmental compliance mission or workload at different installations would demand manpower positions commensurate with the varying work requirements as dictated by the installation size, mission, and local regulatory climate. Since the manpower determinants are based on the statistical processes of correlation and regression analysis, they are designed to produce unbiased and accurate manpower authorizations based on the installation specific workload requirements (3:5-9).

The next logical step is to extend this theory and use the number of environmental manpower positions at a given installation to standardize the number of ECAMP findings at that same installation. In effect, this will allow ECAMP findings comparisons between dissimilar installations that are as unbiased as the manpower determinants themselves.

Ultimately, standardizing ECAMP findings using manpower authorizations derived from manpower determinants should allow unbiased comparisons between dissimilar organizations as recommended by Salthouse, Brown, and Oh (38:3-7). Furthermore, standardizing findings using manpower will allow Air Staff and MAJCOM program managers to compare the total number of ECAMP findings at dissimilar AF installations.

Existing Manpower Determinants

Fortunately, several environmentally-related manpower determinants that could be used to standardize ECAMP findings already exist or are being developed. This section reviews and discusses the literature on four of these determinants. In addition, this section will achieve the first research objective by demonstrating that environmentally-related manpower determinants can be used to standardize ECAMP findings thereby enabling unbiased comparisons between dissimilar AF installations.

Interim Environmental Flight Manpower Determinant.

With the recent AF reorganization, objective wings were implemented on 1 October 1992 (46:1). Under this new structure, the Civil Engineering squadron oversees the installation environmental programs through the objective environmental flight (46:1). As described in the interim Air Force Manpower Determinant (AFMD), the environmental flight is responsible for:

> . . . overseeing cleanup of hazardous waste sites, assisting the Installation Commander to oversee compliance with environmental laws, conducting pollution prevention programs, conducting planning in accordance with the National Environmental Policy Act, and building and managing programs for protection of natural/cultural resources. (48:1)

To ensure that the environmental flight is capable of achieving its mission, a team of experts was assembled to assist the AF Civil Engineering Management Engineering Team (AFCEMET) in developing an AF Manpower Determinant (AFMD) that "provides the manpower needed to support the objective wing environmental flight at all bases with a flying mission" (48:1).

The expert team performed extensive reviews and multiple iterations to determine the environmental processes and activities necessary to accomplish the environmental mission (49:1). Manpower variances were also developed to account for dissimilarities in mission, environmental, and technological factors at each installation (49:1). Additionally, members of the expert team and AFCEMET visited nine bases to field validate the core man-hours and variances (49:1).

The interim AFMD identifies five core processes, hundreds of component activities, total man-hours per month and total man-years for each core activity, and eighteen tentatively approved positive mission variances (15; 47). The five core processes mirror the key elements in the mission statement described above and the mission variances are listed in Table 4. The determinant data is also used to develop a man-hour equation based on four workload factors (48:1). This equation and the corresponding workload factors are shown below:

Man-Hour Equation. $Y = 576.16 + .01077X1 + .003191X2 + .08972X3 + 4.4647X4$

Workload Factor:

X1. The total number of military and civilian personnel (including students) authorized on base.

X2. The total acres of land (under facilities, improved, and semi-improved) on base.

X3. The total number of buildings on base.

X4. The total number of primary aircraft authorized on base including Air National Guard (ANG) and Air Force Reserve (AFR) aircraft. (48:1,2)

TABLE 4

ENVIRONMENTAL FLIGHT VARIANCE SUMMARY AS OF 9 DEC 92

1. Air Force Range Operations
2. Off-base and World-wide Supported Sites
3. Installation with Treatment, Storage, and Disposal Facility
4. Host Nation List
5. Forest Management Plan
6. Forest Fire Management
7. Fish and Wildlife Management
8. Federal/State Threatened and Endangered Species Management
9. Grazing and Cropland Management
10. Coastal, Waterways, and Wetlands Management
11. Historical and Cultural Resource Management
12. Water, Stormwater, Wastewater, and Industrial Wastewater
13. Compliance Agreements (Other Than DERA Related)
14. Air Quality Non-Attainment Areas
15. Special Waste Management
16. Technical Consultation for Private Contractor or Government Owned-Contractor Operated Environmental Management
17. Missile Site Environmental Support
18. Ground Water Monitoring Program

(44:A-1)

Work on the final AFMD is on-going; however, interim applications of the man-hour equation shown above resulted in minimum Y-values of five for bases outside the U.S. EPA jurisdiction and six inside the U.S. EPA jurisdiction (49:3). Based on these results, installations with fewer manpower authorizations than the minimum Y-values were raised to the Y-value while bases with more authorizations than the minimums were fixed at their assigned strength (49:3). Environmental flight manning will remain fixed at these levels until FY 94 when the new AFMD will be applied

(49:1,3). The interim environmental flight manpower determinant is very detailed and attempts to consider the multitude of factors that determine environmental flight workload requirements. There is also a State Regulatory Impact Factor that is used to weight workload factor X2 (acres) based on the "Volume of Regulations and Severity of Enforcement" (15). However, the interim AFMD does acknowledge difficulties associated with applying the traditional least squares regression procedures to core environmental flight manpower requirements. In a section entitled "Practical Considerations" the interim AFMD states:

> Actions required to maintain the installation in a state of compliance originate in Public Law and are not discretionary. The factors truly predicting manpower requirements are contained in the millions of pages of regulations with which each installation must comply to avoid pollution of the environment, avoid willful and knowing endangerment of Flight and base staff members, and avoid potential civil and/or criminal actions for acts of both commission and omission. Environmental law does not require "intent" to violate a statute as a minimum threshold to be prosecuted. Knowledge that one is breaking the law is not always readily discernable considering the explosion of environmental regulations with over 55,000 pages of new regulations published since 1982. (49:5)

Although the concerns described above are valid, the interim environmental flight manpower determinant is being applied in all objective wings, and it considers numerous factors including installation size, mission, and local regulatory climate in determining environmental flight manpower authorizations. Thus, using the installation specific manpower authorizations derived with this determinant to standardize installation ECAMP findings should allow unbiased comparisons between dissimilar installations with objective wings.

Environmental Management Manpower Determinant. At the present time, the interim environmental flight manpower determinant does not apply to former Air Force Logistics Command (AFLC) installations (37). Instead, an indepth study of the man-hour requirements necessary to accomplish the workload of the former AFLC (now Air Force Materiel Command) Directorate of Environmental Management functions published on 17 January 1992 is being used (19:1-1). This study used operational audit techniques to collect workload data for all seven Environmental Management (EM) Directorates (19:1-1). This data revealed 17 workload categories and hundreds of sub-tasks (19:1-1). These categories are similar to the core processes, and the sub-tasks parallel the component activities in the interim environmental flight manpower determinant.

Statistical analyses were performed on the data, and regression models were used to develop a modular equation application matrix (19:A4-2). This matrix includes regression equations for six of the seventeen workload categories, and these equations use the eleven workload factors shown in Table 5 (19:1-1).

TABLE 5

ENVIRONMENTAL MANAGEMENT DIRECTORATE WORKLOAD FACTORS

X1.	DD Form 1348s Processed
X2.	AF Form 813s (Request for Environmental Impact Assessment) Reviewed
X3.	Environmental Assessments Completed
X4.	Construction Projects Reviewed
X5.	Permitted Outfalls Managed
X6.	Constituents on Industrial Waste Treatment Plant Permit
X7.	National Priorities List (NPL) Sites Managed
X8.	Non-NPL Sites Managed
X9.	Hazardous Materials Spills
X10.	Asbestos Air Samples Taken
X11.	Asbestos Contract Projects

(19:1-1)

Although the six equations and eleven workload factors identified in the EM manpower determinant are vastly different from the single regression equation and five workload factors identified in the environmental flight manpower determinant, both procedures systematically apply statistical methods to determine manpower requirements based on the varying levels of environmental workload at dissimilar installations. Overall, the EM determinant accounts for the differences between installations by increasing both the number of equations and workload factors while the environmental flight determinant accounts for these differences by using simpler equations and fewer workload factors but allowing complex installation specific variances. In essence, both methods are of comparable complexity, and they attempt to achieve the same goal for installations in different commands.

In summary, the EM manpower determinant is being applied at all AFMC installations with EM Directorates, and it considers numerous workload factors that are influenced by installation size, mission, and local regulatory enforcement. Thus, using the installation specific manpower authorizations derived using this determinant to standardize installation ECAMP findings should allow unbiased comparisons between different AFMC installations with EM functions.

Bioenvironmental Engineering Manpower Determinant.

The Bioenvironmental Engineering (BEE) manpower determinant is another existing environmentally-related manpower determinant that applies to all installations authorized functional account code (FAC) 5311 except AFMC bases(17:1). Unlike the recently developed environmental flight and EM manpower determinants the BEE AFMD has been used since the early 1980s, and it has gone through two major revisions. The current June 1991 AFMD, which supersedes the July 1985 version, is based on an operational audit of historical records and technical estimation techniques (17:1). In contrast, the EM manpower determinant study concluded that:

> Due to the relative young age of the Environmental Management organization, the lead team felt it prudent to delay total development of the management decision package until at least the next measurement. Only 6 of

> 17 functional categories of work were performed in a similar enough manner to produce an acceptable correlation coefficient. As the organization matures, and more measurement data is collected, the management decision package can be developed. (19:1-1)

In effect, the BEE manpower determinant may be a better standardizing factor since it has matured over time with the developing environmental legislation. In contrast, environmental flight and EM manpower authorizations have had a tendency to increase significantly at different times in response to local politics, environmental problems, and organizational or policy changes. For instance, Brunner indicates that:

> . . . during the mid-1980s, it became clear to McClellan's management that we had to change the way we did business. Base environmental resources had to be consolidated and expanded in order to meet the growing environmental problems that the base faced. (8:186)

In response to these factors, McClellan's dedicated environmental positions grew almost immediately from five or fewer people to thirty-one (8:187). By April 92, the number was 60, and as of February 93 there were 84 dedicated environmental positions (8:187; 37). Similarly, several installations with objective environmental flights saw their manpower authorizations immediately raised as a result of the policy decision to increase all objective flight manpower levels to the core values developed under the interim environmental flight manpower determinant (49:3).

Like the EM and environmental flight AFMDs, the BEE AFMD is designed to quantify the manpower requirements necessary to accomplish the tasks described in the work center description for the varying levels of workload at dissimilar installations. The similarities between the tasks or activities in the work center descriptions for the EM and BEE manpower determinants are illustrated in Tables 6 and 7. Table 6 lists the 17 major headings from the EM work center description, and Table 7 lists similar major headings and subheadings from the BEE work center description.

TABLE 6

EM WORK CENTER DESCRIPTIONS

1. Hazardous Waste Program
2. Hazardous Materials Program
3. Natural Resources
4. Cultural Resources
5. Environmental Compliance Assessment and Management Program (ECAMP)
6. Environmental Impact Analysis Process (EIAP)
7. Resource Management
8. Air Quality Program
9. Water Quality Program
10. Restoration Program
11. Storage Tank Program
12. Spill/Response and Planning
13. Manage Asbestos Program
14. PCB Program
15. Solid Waste Management Program
16. Project Management
17. Hazardous Waste Minimization Program

(19)

TABLE 7

BEE WORK CENTER DESCRIPTIONS

1. Construction, Process Order, and Equipment Design Review
2. Issue Exception (IEX) Coding Program for Hazardous or Toxic Substances
3. Workplace Environmental Evaluation
    - 3.2.3.8 Collects Pollution Control Data
    - 3.2.3.9 Updates Hazardous Material Data
4. Community Environment
    - 4.1 Assesses Potable Water Quality
    - 4.1.1.3 Provides Notification of Noncompliance
    - 4.4 Environmental Compliance Assessment and Management Program (ECAMP)
5. Water and Air Pollution Monitoring
    - 5.2 Performs National Pollution Discharge Elimination System (NPDES) Monitoring
    - 5.3 Performs Annual Air Pollution Emission Inventory
    - 5.4.5 Conducts Visual Emission Survey
    - 5.5 Assists Civil Engineering With State or Local License or Permit Request
    - 5.6 Maintains Pollution Data
    - 5.7 Participates in Installation Restoration Program
9. Fuel Tank Cleaning Monitoring and Inspection
11. Supports On-Base Functions Provided By Maintenance and Services Contracts
13. Resource Conservation and Recovery Act (RCRA) Monitoring and Training
    - 13.3 Conducts Compliance Survey
    - 13.5 Performs Waste Stream Characterization
16. Hazard Communication (HAZCOM) Program
    - 16.1.3 Conducts Chemical Inventory
    - 16.2 Researches and Updates Hazardous Material Data

(17)

Although the two tables are not identical, close inspection reveals definite similarities. For instance, items 8 and 9 in Table 6 identify air and water quality programs as primary EM work center activities while item 5 in Table 7 lists water and air pollution monitoring as a primary BEE work center tasking and then goes on to specify numerous air and water pollution monitoring sub-taskings. The sub-tasking levels in the BEE work center description may also indicate that the BEE manpower standard has evolved over time to include more detailed environmentally-related workload factors then the relatively young EM manpower determinant.

The BEE AFMD is also similar to the interim environmental flight manpower determinant in that it is based on man-hour equations and workload factors (17:1). However, the BEE manpower determinant is based on two man-hour equations and two workload factors whereas the interim environmental flight AFMD is based on one equation with four workload factors (17:1; 48:1,2). The BEE man-hour equations and workload factors are shown below.

Man-hour Equations.

(1) $Y1 = 441.2 + 0.1519X1 + 6.890X2$ for locations which earn at least 803.603 man-hours after applying Equation Y1.

(2) $Y2 = 332.8 + 0.1706X1 = 1.324X2$ for locations which earn less than 803.603 man-hours after applying Equation Y1.

Workload Factors:

(1) X1. Selected authorized military and civilian population.

(2) X2. Air National Guard, Air Force Reserve, Area Radar Sites, and other DoD Installations Supported by an attending Bioenvironmental Engineer. (17:1)

Comparing the BEE workload factors with the interim environmental flight workload factors discussed earlier reveals that both groups of variables consider the number of authorized personnel and Air National Guard and Air Force Reserve activities. Furthermore, the workload factors in the July 1985 BEE AFMD were almost identical to those currently proposed for environmental flight. The 1985 BEE workload factors included values for selected military and civilian Air Force Specialty Codes (AFSCs), total acreage, total number of assigned aircraft, and the number of supported installations (17:3).

In general, the BEE AFMD is another existing, statistically based manpower determinant that applies to all AF installations except AFMC bases. Like the EM and interim environmental flight AFMDs discussed earlier, it is designed to consider installation size and mission variabilities. Furthermore, the BEE workload factors, workload descriptions, and environmental taskings are also similar. Moreover, the BEE AFMD may be a better standardizing factor since it has a longer history and has matured over time with the evolving environmental legislation. In essence, using the BEE manpower authorizations to standardize the corresponding installation ECAMP findings should allow unbiased comparisons for all AF bases except AFMC installations.

AFMC BEE Manpower Determinant. Just as separate manpower determinants were developed for the EM functions at AFMC installations, separate determinants were also developed for Bioenvironmental Engineering sections at these large and complex installations. Like the BEE manpower determinant just discussed, the AFMC BEE manpower determinant has been evolving with time. The most recent functional review was initiated in July 1991, the workload measurement period was from 1 December 1989 to 31 November 1991, and the final report was completed in October 1992 (2:1-2). Overall, this study was similar to those previously discussed; however, the findings, data analysis, and determinant development provide additional unique insights.

The work center descriptions developed in this study closely parallel the descriptions used in the BEE AFMD for non-AFMC installations (key portions of which were previously identified in Table 7); however, nine new categories of work were identified (2:3-2). These categories support the covariation between BEE and environmental workloads, and they are listed in Table 8.

TABLE 8

NEW BIOENVIRONMENTAL ENGINEERING WORKLOAD CATEGORIES

18.1	Manages Data	
	18.1.1.4	Prepares Environmental Monitoring data
19.	Workplace Biomonitoring	
20.	Biological Waste Disposal Program Monitoring to Assess Compliance with Federal, State and Local Regulations	
22	Hazardous Waste Operation and Emergency Response Medical Support Program	
23	Indoor Air Quality (IAQ) Program	
24	Occupational Exposure to Hazardous Chemicals in Laboratories	
25	Hazardous Identification and Abatement of Lead-Based Products in Housing and Public Facilities	
26	Technical Order Review	
	26.3.2	Reviews Toxicity Resource Recovery, Hazardous Waste (Minimization, Substitution, Disposal), Physical, Biological Hazards or Other Related Topics
27	Installation Restoration Program (IRP)	

(2:3-2)

During this study, nine potential workload factors were reviewed including total authorized personnel, installation acreage, and total square footage of base facilities (2:3-3). However, due to extreme workload variation from installation to installation, it was difficult to develop one or two standardized manpower equations (2:3-3). Instead, separate regression equations were derived for each installation using the total base populace as the X-value, a constant slope or b-value, and an installation unique a-value (2:3-3). The study also concluded that:

> Things such as state and local laws and regulations; base and local community interest items; directives

from MAJCOM level and higher; and the amounts of hazardous material used and stored on the base all determine what is or is not at BEE priority. (2:3-3)

Ultimately, the AFMC BEE functional review supports the need to consider installation size, mission, and local laws and regulations when selecting a standardization factor. Additionally, using the manpower authorizations derived from the installation specific manpower regression equations to standardize ECAMP findings should allow unbiased comparisons between dissimilar installations within AFMC.

Summary

Environmental auditing has many definitions and numerous terms are used to describe the process; however, the primary objective of environmental auditing is to assess and improve environmental compliance. Although environmental auditing is a relatively new and evolving discipline, the literature indicates that the seven key elements discussed in the 1986 EPA Environmental Auditing Policy Statement remain valid indicators of effective environmental auditing programs.

Moreover, current trends indicate that the American public now expects routine environmental audits by independent sources. These expectations are causing companies to focus audits on environmental management systems and their abilities to identify and assess both existing and potential environmental compliance problems.

In 1988, the AF established and implemented an environmental auditing program known as ECAMP. Like other auditing programs, ECAMP uses internal and external assessments to evaluate AF environmental compliance. Subsequently, noncompliance findings frequently have significant impacts on installation resource allocation decisions. To ensure that resources are properly allocated and apportioned among competing environmental compliance requirements, AF decision-makers need meaningful environmental compliance measures. Furthermore, comparing ECAMP results and measuring overall program effectiveness is critical to ensuring environmental compliance. However, quantifying the relationship between environmental compliance and ECAMP findings is difficult, and current ECAMP metrics focus on expeditious finding resolution without systematically considering overall program effectiveness or assessing future noncompliance probabilities.

Ideally, Air Staff and MAJCOM decision-makers should be able to compare the total number and type of ECAMP findings from various installations and identify the installations that require resources to prevent future environmental problems and improve environmental compliance. However, before ECAMP findings can be compared, these findings probably need to be weighted or standardized to account for dissimilarities between installations.

Ultimately, installation specific environmental compliance requirements are a function of installation size, mission, and local regulatory enforcement. Similarly, ECAMP findings are a function of the corresponding installation specific environmental compliance requirements. Thus, there should be a direct relationship between the number of ECAMP findings and environmental compliance.

To quantify this relationship, and compare ECAMP findings between dissimilar installations, a weighting or standardizing factor that accounts for installation specific size, mission, and environmental compliance requirements would be useful. Fortunately, several environmentally-related manpower determinants that are statistically derived and specifically designed to produce unbiased manpower authorizations based on installation workload requirements already exist.

The literature describing the development of the Interim Environmental Flight, AFMC Environmental Management, Bioenvironmental Engineering, and AFMC Bioenvironmental Engineering manpower determinants indicates that all four developmental procedures systematically apply observational, data collection, and statistical methods to determine specific manpower requirements based on the varying levels of environmental workload at dissimilar installations. Ultimately, each determinant makes a comprehensive effort to consider all relevant workload requirements as dictated by installation size, mission, and local regulatory enforcement. In essence, using each determinant to standardize ECAMP findings for the respective installations where they are currently being applied should allow unbiased comparisons of ECAMP findings from dissimilar installations using the same manpower determinant. However, the BEE manpower determinant may be a better standardizing factor since it has matured over time with the developing environmental legislation. Furthermore, comparing and statistically analyzing the standardized findings using the respective BEE and environmental AFMDs may prove valuable.

Conclusion

The literature review clearly demonstrates that the increasing number of AF NOVs is inconsistent with AF environmental compliance goals, ECAMP objectives, and successful environmental auditing program characteristics. Moreover, the present ECAMP metrics measure program effectiveness within ECAMP while a true metric should measure performance external to the program through improved environmental compliance. To improve compliance and become a national leader in protecting and enhancing the environment, the AF needs a metric relating standardized ECAMP findings and historical NOV data to assist decision-makers in identifying the installations that require resources to prevent future environmental problems and improve environmental compliance. Thus, research into developing such a metric or model is needed. If successful, this research could assist AF decision-makers in properly allocating and apportioning scarce resources among installations with competing environmental compliance requirements. In addition, the development of such a metric or model could assist decision-makers in improving ECAMP effectiveness thereby reducing NOVs and preventing fines and penalties pursuant to the Federal Facilities Compliance Act.

III. Methodology

Overview

This chapter describes the methodology that was used to investigate the three research objectives outlined in Chapter I:

1. Demonstrate that environmentally-related manpower determinants can be used to standardize ECAMP findings thereby enabling unbiased comparisons between dissimilar AF installations.

2. Develop a methodology that uses the standardized ECAMP findings and historical NOV data to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance.

3. Test, evaluate, and revise the methodology for possible use throughout the AF.

Overall, this research addresses two problems. First, the validity of using existing environmentally-related manpower determinants as standardizing factors was subjectively established in the literature review. Next, a methodology using standardized ECAMP findings and historical NOV data to assist AF decision-makers in identifying installations that require resources to prevent future environmental problems and improve environmental compliance was developed, tested, and evaluated. Finally, the methodology was revised and an ECAMP effectiveness model was proposed, tested and evaluated. Based on these results, it was recommended that Air Staff and MAJCOM environmental leaders review the research and consider using the proposed ECAMP Effectiveness Model as a metric to measure ECAMP effectiveness and improve environmental compliance.

Data Collection

This section describes and discusses the various data collection activities that occurred during this research. Due to the sensitive nature of NOV and ECAMP information, MAJCOMs requested that the identity of the individual bases involved in the study not be disclosed. To maintain this confidentiality, code letters and numbers were assigned to each base in the data set. The actual names of the installations were recorded by the researcher but do not appear in the thesis.

Manpower Authorization Data. The BEE manpower authorization data used for the standardization process was acquired from the MAJCOM BEE offices at AFMC, AMC, and ACC. Similarly, interim environmental flight and environmental management manpower authorization figures were obtained from the environmental offices at the respective commands.

ECAMP Data. The external ECAMP data analyzed in this research was also acquired from the MAJCOM environmental offices. Fifty-nine bases were identified as potential candidates for study; thirty-four, thirteen, and twelve from ACC, AMC, and AFMC respectively. Initial plans to randomly select the bases for the study were changed based on conversations with the individual MAJCOM ECAMP managers. These conversations revealed that external ECAMP reports prior to 1991 were not readily available (9; 29; 42). Thus, the ACC and AMC program managers were asked to provide as many external ECAMPs as possible, and all available AFMC external ECAMPs were obtained by visiting the program manager.

As a result of these activities, external ECAMP findings from 49 bases were collected. Overall, 30 ACC, 12 AFMC, and 7 AMC installations are represented in the data set. However, only 35 of these evaluations, 22 ACC, 9 AFMC, and 4 AMC, were performed at least one year prior to the NOV information obtained from the RCOs.

NOV Data. Historical NOV data was acquired from the RCO data bases. This information included all NOVs received by the AF prior to 25 March 1993. The installation specific NOV data was then used to assess the relationships between NOVs and standardized ECAMP findings for 1-year periods prior to and following the ECAMP evaluations. Descriptive statistics were also used to evaluate the historical NOV data for the 59 bases in the potential sample population. This information was used to determine realistic values for the average number of NOVs used in the ECAMP effectiveness model.

General Methods

This section outlines the general methods that were used to achieve the three research objectives.

Objective 1. In Chapter II, a comprehensive review of the literature describing the development of the Interim Environmental Flight, AFMC Environmental Management, Bioenvironmental Engineering, and AFMC Bioenvironmental Engineering manpower determinants revealed that all four developmental procedures systematically apply observational, data collection, and statistical methods to determine specific manpower requirements based on the varying levels of environmental workload at dissimilar installations. In addition, each determinant makes extensive efforts to consider all relevant workload requirements as dictated by installation size, mission, and local regulatory enforcement.

Thus, the literature review subjectively demonstrated that using each determinant to standardize installation ECAMP findings for the respective installations where they are currently being applied should allow unbiased comparisons of ECAMP findings from dissimilar installations using the same manpower determinants.

Next, the manpower authorizations derived using the two BEE determinants were compared to the manpower authorizations obtained using the corresponding Interim Environmental Flight, and AFMC Environmental Management determinants and statistical regression analyses were performed to determine correlations between the standardizing factors. The coefficients of determination and the information obtained during the literature review were then be used to select the standardizing factors for the installations in the sample population. These factors were then used to standardize historical ECAMP findings from specific AF installations.

Objective 2. To achieve objective 2, standardized ECAMP findings were compared to historical NOV data for the respective installations in a pilot study. The objective of the pilot study was to test the theory that there should be a direct relationship between the number of standardized ECAMP findings and environmental compliance. Regression analyses were used to assess the significance of the relationships.

Based on these results, the study was expanded to see if significant relationships existed between both standardized and unstandardized ECAMP findings and NOVs for 35 AFMC, ACC, and AMC installations. Again, regression analyses were used to assess the significance of the relationships. The methodology was then revised and an ECAMP effectiveness model was proposed.

Objective 3. The proposed ECAMP effectiveness model was then tested and evaluated using 24 bases in the data set with external ECAMP evaluations in 1991 or 1992 and with NOV data from both 1-year prior to and 1-year after the evaluation. First, lines representing the average numbers of NOVs and standardized ECAMP findings were drawn on the scatter plots to define four ECAMP effectiveness quadrants. Next, ECAMP effectiveness was determined by plotting NOVs from 1-year prior to and 1-year after the evaluations against standardized major and total ECAMP findings. The results were then evaluated using a tabular format and the standard AF rating system of unsatisfactory, marginal, satisfactory, and excellent. Additional analyses using unstandardized ECAMP findings demonstrated the flexibility of the proposed model and suggested that the BEE standardization factor does account for the dissimilarities between large and small installations as expected and desired.

Based on this analysis, the proposed ECAMP effectiveness model should allow AF decision-makers to quickly and easily identify installations with effective ECAMP programs and those bases where ECAMP programs need more attention and/or resources. Ultimately, the proposed ECAMP effectiveness model should assist decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance.

Summary

The research methodology described in this chapter uses readily available manpower authorization, ECAMP finding, and NOV data to develop, test, evaluate, and revise a methodology to assist decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance. If approved and implemented by the AF, the resulting ECAMP Effectiveness Model could assist decision-makers in properly allocating and apportioning scarce resources among installations with competing environmental compliance requirements. Moreover, using the proposed model should assist decision-makers in improving ECAMP effectiveness thereby reducing NOVs and preventing fines and penalties pursuant to the Federal Facilities Compliance Act.

IV. Results and Analyses

Overview

This chapter contains four main sections labeled manpower data analysis, pilot study, expanded study, and proposed ECAMP Effectiveness Model. Each main heading includes three sub-sections that provide background information, describe and discuss research results, and summarize section findings. Specific section previews are also provided to introduce the discussions for each main area.

Manpower Data Analysis

This section provides background information on regression analysis, describes and discusses the results of six manpower regression analyses, summarizes overall regression analyses findings, and concludes that BEE manpower authorizations will be used as the primary standardization factor throughout the remainder of the research.

Background. The first step in the data analysis process was to evaluate the relationships between the respective environmental and BEE manpower authorizations. Devore states that,

> Regression analysis is the part of statistics that deals with investigation of the relationship between two or more variables related in a nondeterministic fashion. (20:454)

One of the main purposes of regression analysis is to estimate or predict values for the dependent variable (Y) given values for the independent variable (X) (41:259). Using the simple linear regression model, a deterministic mathematical relationship can then be established between the two variables in the form of a straight line described by the equation $E(Y) = A(X) + B$, where $E(Y)$ is the expected value of the dependent variable Y, A is the slope, and B is the y-intercept (20:454). Coefficients of determination, denoted by r^2, are then calculated.

Results. The resulting r^2 values describe the proportion of observed variation in Y that can be explained by variations in X. For example, an r^2 value of 0.9 means that 90 percent of the variations in Y can be explained by variations in X (20:467). The data used in the manpower regression analyses is provided in Appendix A, and Figure 3 graphically illustrates the regression analysis of the manpower authorization data for 27 ACC, 12 AFMC, and 12 AMC installations.

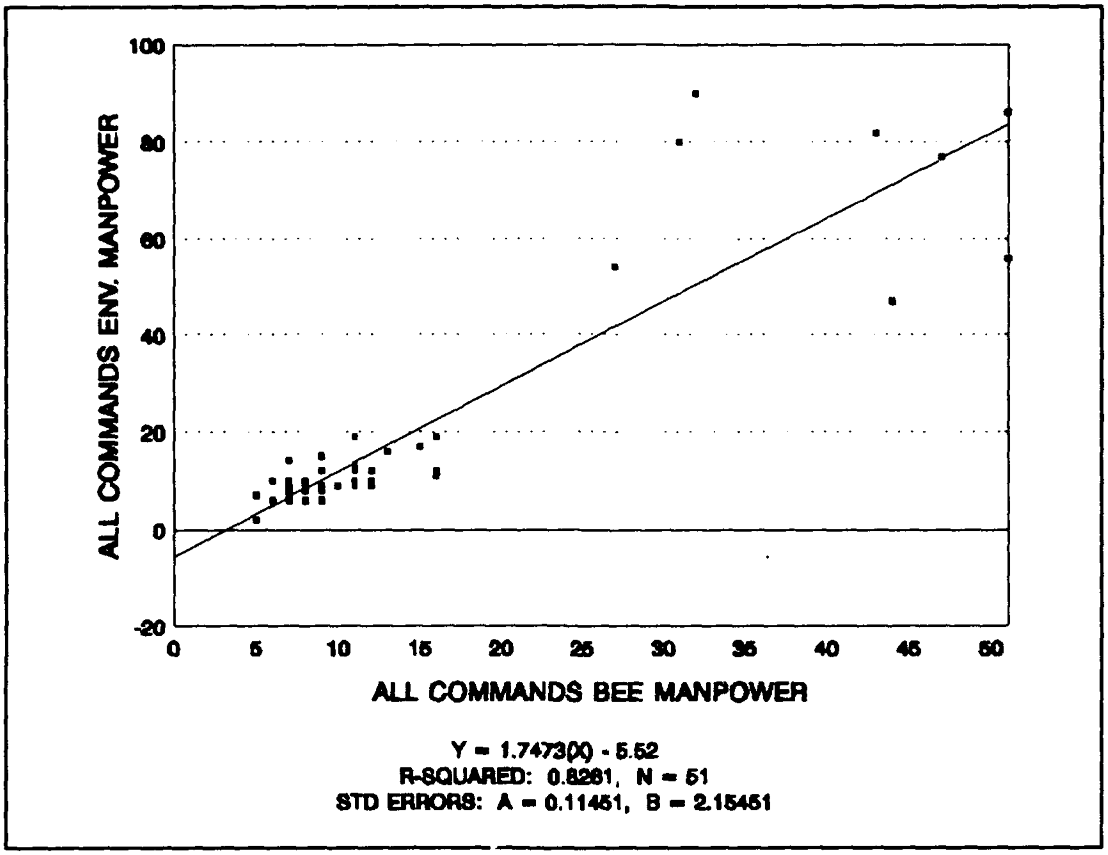

Figure 3. Manpower Regression Analysis, 51 Installations

The r^2 value of 0.8261 suggests that approximately 82% of the variations in environmental manpower authorizations (Y) can be explained by the variations in BEE manpower authorizations (X). This is a fairly high correlation given that the data includes manpower authorizations from three commands, derived using four manpower determinants as discussed in Chapter II. In addition, the majority of the environmental manpower values (27 ACC and 12 AMC) are based on the interim environmental flight manpower determinant which is still developing and changing. This may partially explain the decrease in r^2 values for the command specific manpower regression analyses.

A plot and the command specific regression analysis results for 12 AFMC installations are shown in Figure 4.

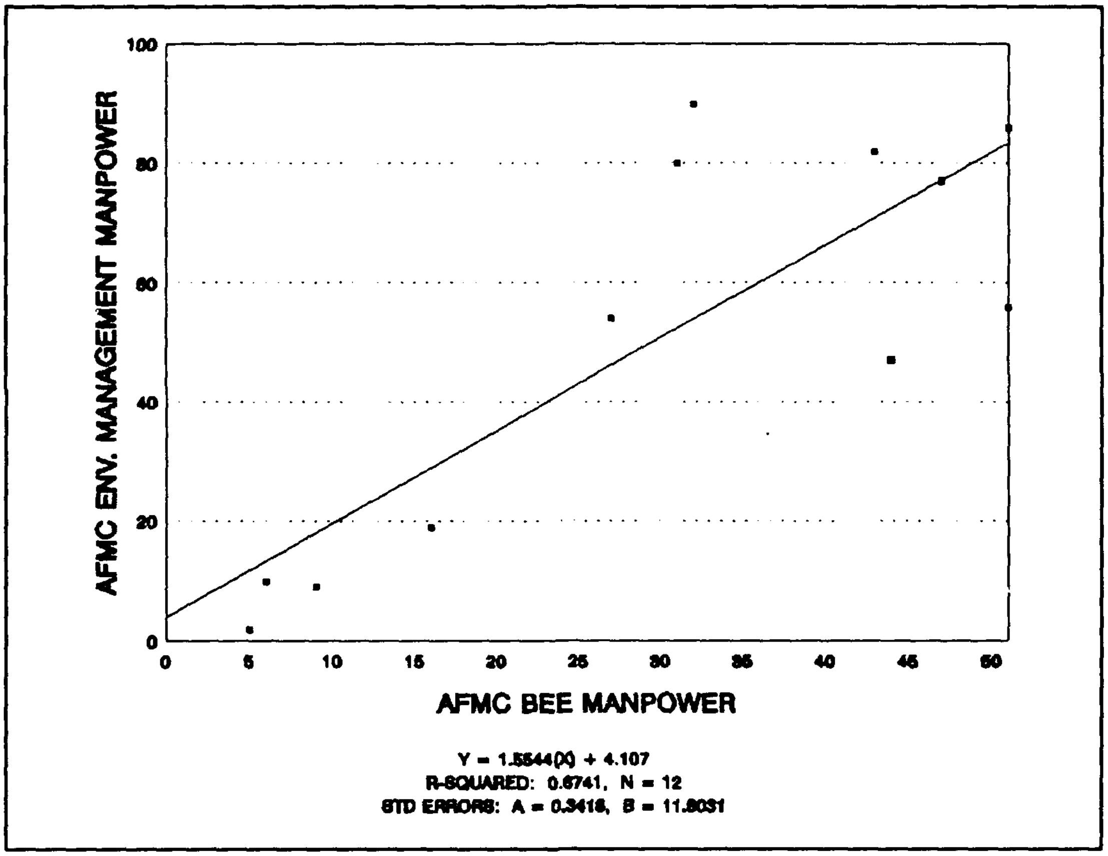

Figure 4. Manpower Regression Analysis, 12 AFMC Installations

Six of the twelve data points in Figure 4 are based on the EM and BEE manpower determinants developed specifically for the former logistics centers as discussed in Chapter II.

The remaining six data points are based on the actual April 1993 EM and BEE manpower authorizations as obtained from the MAJCOM offices. As previously alluded to, the r^2 value for the 12 AFMC bases decreased to 0.6741 as compared to 0.8261 for all 51 installations. The lower r^2 values are not unexpected due to the relative young age and developing status of AFMC environmental organizations. To gain a better understanding of the dynamic, evolving nature of both AF and AFMC environmental organizations, two additional regression analyses were performed using AFMC manpower data from specific time periods. The actual data used in these analyses are presented in Appendix B.

First, the historical AFMC environmental manpower authorizations from April 1992 are plotted and analyzed. During the one year period between April 1992 and April 1993, nine AFMC environmental organizations experienced increases in manpower authorizations, two had authorizations remain the same, and one organization experienced a slight manpower authorization decrease while BEE manpower remained constant. The r^2 value for this analysis was 0.5550 as compared to the 0.6741 value calculated using the April 1993 data. This improvement seems to suggest that the relationship between AFMC environmental manpower and AFMC BEE manpower is becoming stronger as the environmental organizations mature. Figure 5 displays the results of the first analysis using the April 1992 AFMC manpower data.

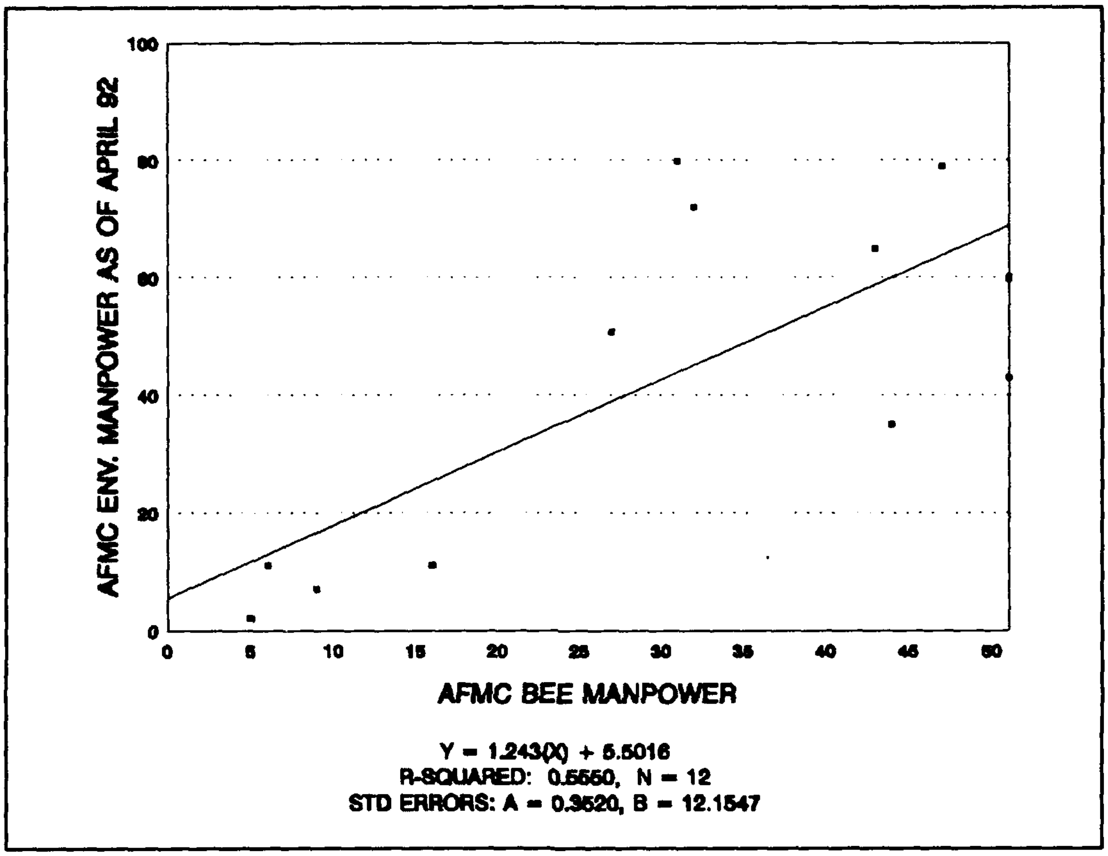

Figure 5. Regression Analysis Using April 1992 Data

Next, the actual number of AFMC personnel assigned as of April 1993 was used in the regression analysis. An examination of this data reveals that eight installations had fewer people assigned then authorized while two had more and two were manned at the required level. Figure 6 shows the plot and regression analysis results using the actual AFMC manpower data from April 1993.

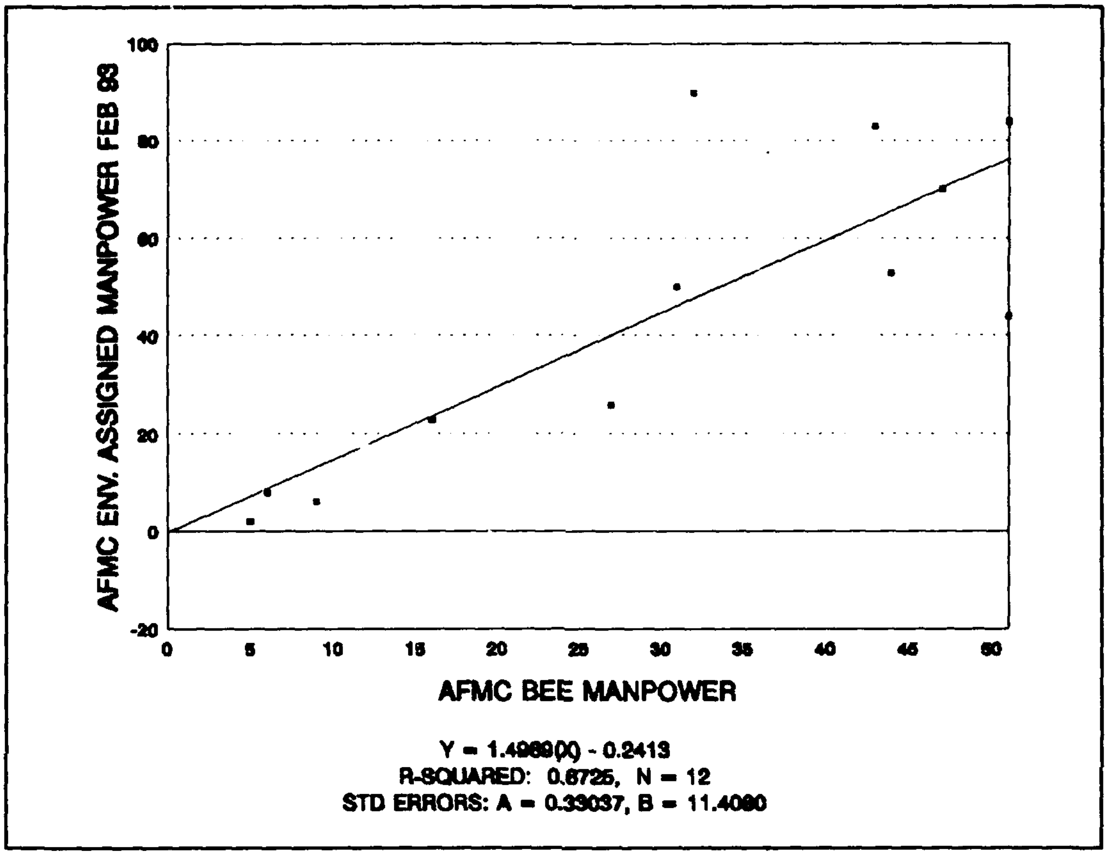

Figure 6. Regression Analysis, 12 AFMC Bases Actual Manning April 1993

The r^2 value for the actual environmental manning analysis was 0.6725 as compared to the 0.6741 value calculated using the required manning over the same time period. Although only two of twelve installations were actually manned at authorized levels, the fact that these two r^2 values are essentially the same could suggest that true workload conditions at the installations are causing environmental manning to change in a fashion similar to the maturation process previously experienced by BEE manning.

The hypothesis that the relationship between environmental manpower and BEE manpower will become stronger as the environmental organization matures could also be supported by the ACC and AMC command specific manpower regression analyses. Plots and the regression analysis results for the 27 ACC and 12 AMC installations are shown in Figures 7 and 8 respectively.

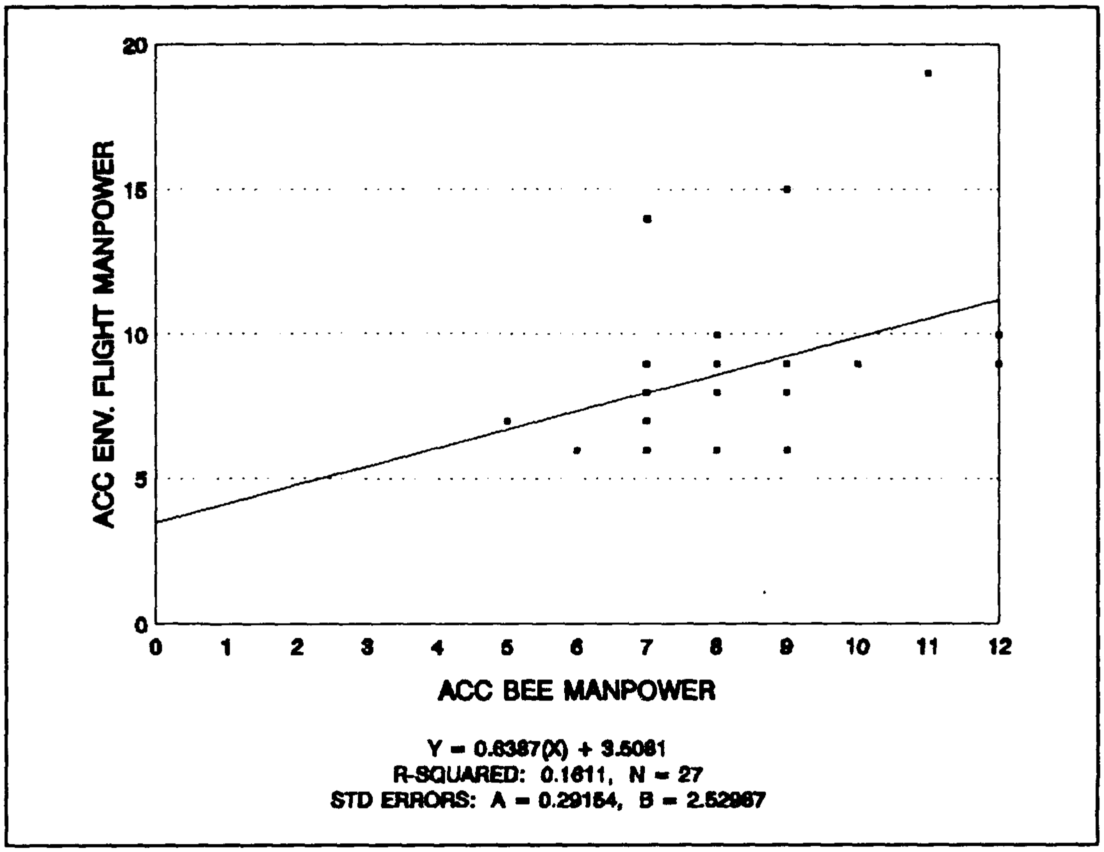

Figure 7. Manpower Regression Analysis, 27 ACC Installations

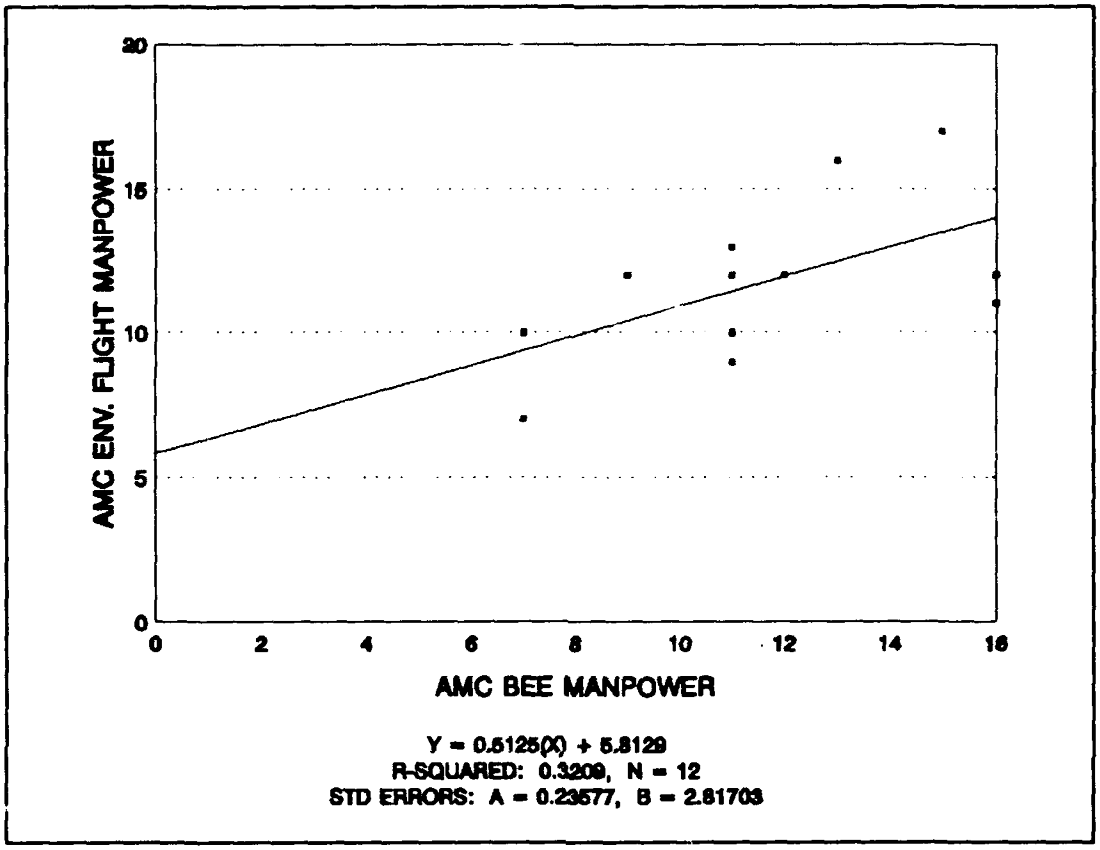

Figure 8. Manpower Regression Analysis, 12 AMC Installations

Although the ACC and AMC r^2 values of 0.1611 and 0.3209 indicate that only 16 to 32% of the variations in environmental manpower authorizations (Y) can be explained by the variations in BEE manpower authorizations (X), low r^2 values were not unexpected since all 39 data points are based on the interim environmental flight manpower determinant which is still developing and changing. In effect, these low r^2 values could support the theory that the relationship between environmental and BEE manpower is becoming stronger as the environmental organizations mature if the correlation increases with time as appears to have been the case with the AFMC environmental management manpower determinant.

Summary. The regression analysis for 27 ACC, 12 AFMC, and 12 AMC installations resulted in a coefficient of determination of 0.8243. This value suggests that the overall or macro-level relationship between BEE manpower and environmental manpower is relatively strong. Although command specific or micro-level regression analyses resulted in significantly lower coefficients of determination, these values were not unexpected based on the relative young age and developing status of the various environmental organizations and the respective manpower determinants. The r^2 values for the ACC and AMC analyses where all the data points are based on the new and changing interim environmental flight manpower determinant were the lowest at 0.16 and 0.32 respectively. However, the r^2 value for the more established AFMC environmental data increased to 0.6741. Furthermore, a more detailed analysis of the historical AFMC environmental authorizations suggests that the relationship between AFMC environmental manpower and AFMC BEE manpower is becoming stronger as the environmental organizations mature.

Overall, the regression analyses of the manpower authorization data indicate that the relationship between BEE manpower and environmental manpower is relatively strong at the macro-level and weak but possibly becoming stronger at the micro-level. In general, these regression analyses support the Chapter II conclusion that the BEE manpower determinant may be the best standardizing factor since it has matured over time with the developing environmental legislation. Thus, BEE manpower authorizations will be used as the primary standardization factor in the pilot study and throughout the remainder of this research.

Pilot Study

This section provides background information on the pilot study objective, describes and discusses the results of six regression analyses performed to assess the relationship between NOVs and standardized ECAMP findings, summarizes overall regression analyses findings, and concludes that an expanded study is justified.

Background. The objective of the pilot study was to test the theory that there should be a direct relationship between the number of standardized ECAMP findings and environmental compliance. It was proposed that the number of NOVs received 1-year after an external ECAMP evaluation should be dependent upon the number of findings contained in the ECAMP report after the findings had been standardized using BEE manpower authorizations. To test this theory, all available reports for AFMC external ECAMP evaluations performed 1-year prior to the date of the NOV data provided by the RCOs, 25 March 1993, were obtained by visiting the AFMC ECAMP program manager. Based on this criteria, the numbers of major and total ECAMP findings were then extracted from the reports for nine AFMC installations. These numbers were then divided by the number of BEE manpower authorizations at the respective bases to produce standardized findings. The number of NOVs received by the respective installations within 1-year following the ECAMP evaluation were then obtained from the RCO data and plotted against the standardized findings. Regression analyses were then performed to investigate the relationship between the number of NOVs (Y) and the number of standardized ECAMP findings (X).

Results. The results of the six regression analyses performed to assess this relationship are described and discussed in this sub-section, and the AFMC data used in the pilot study regression analyses are shown in Table 9.

TABLE 9

AFMC PILOT STUDY DATA

(1) BASE	(2) MAJOR ECAMP FINDINGS	(3) TOTAL ECAMP FINDINGS	(4) NOVs SINCE ECAMP	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
AFMC-1	47	82	3	9	5.22	9.11
AFMC-3	24	56	1	44	0.55	1.27
AFMC-4	68	101	5	51	1.33	1.98
AFMC-5	54	74	2	16	3.38	4.63
AFMC-6	55	113	0	43	1.28	2.63
AFMC-7	67	85	7	32	2.09	2.66
AFMC-9	44	88	5	47	0.94	1.87
AFMC-10	119	156	3	27	4.41	5.78
AFMC-12	48	75	4	51	0.94	1.47

The values in columns six and seven of Table 9 are obtained by dividing the second and third columns by the BEE standardization factors in column five. The number of NOVs in column four was then plotted against the number of standardized findings in the last two columns and regression analyses were performed. Plots and regression analysis results for the nine AFMC installations in the pilot study are shown in Figures 9 and 10. Specifically, Figure 9 plots NOVs against standardized major ECAMP findings while Figure 10 displays the relationship between NOVs and standardized total ECAMP finding.

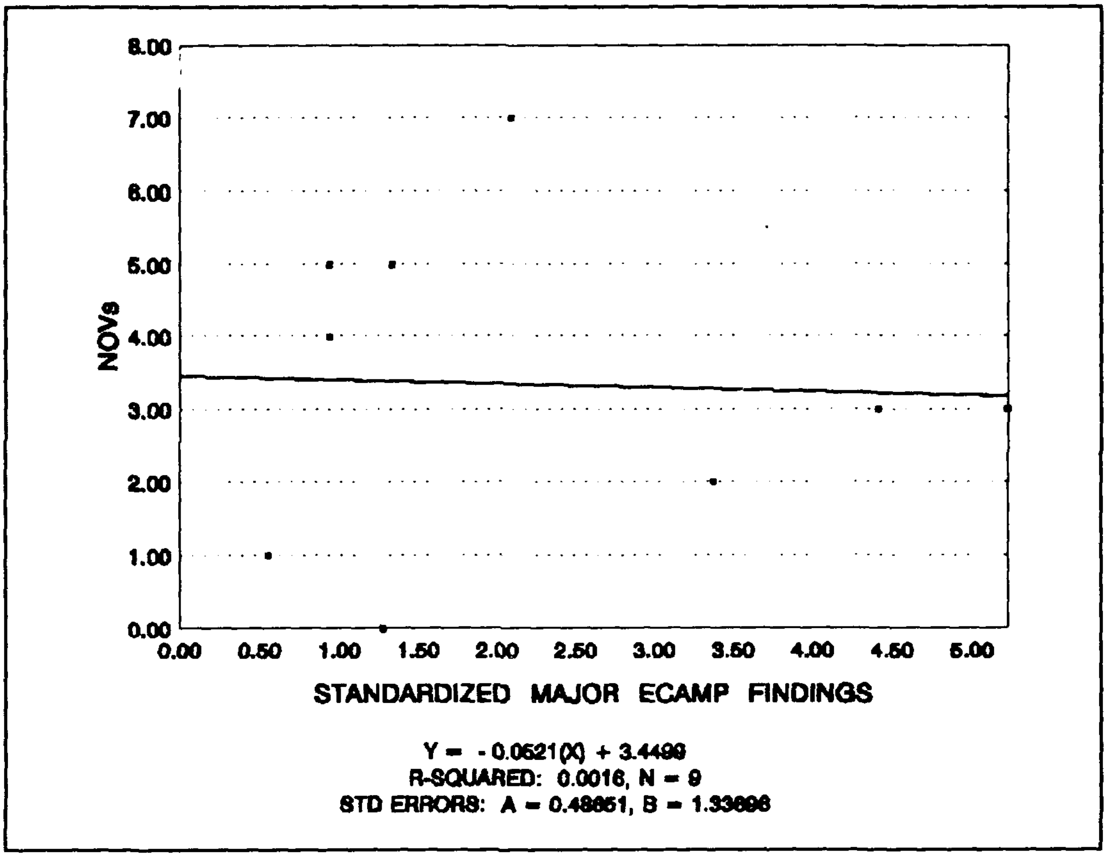

Figure 9. Regression Analysis, Major ECAMP Findings

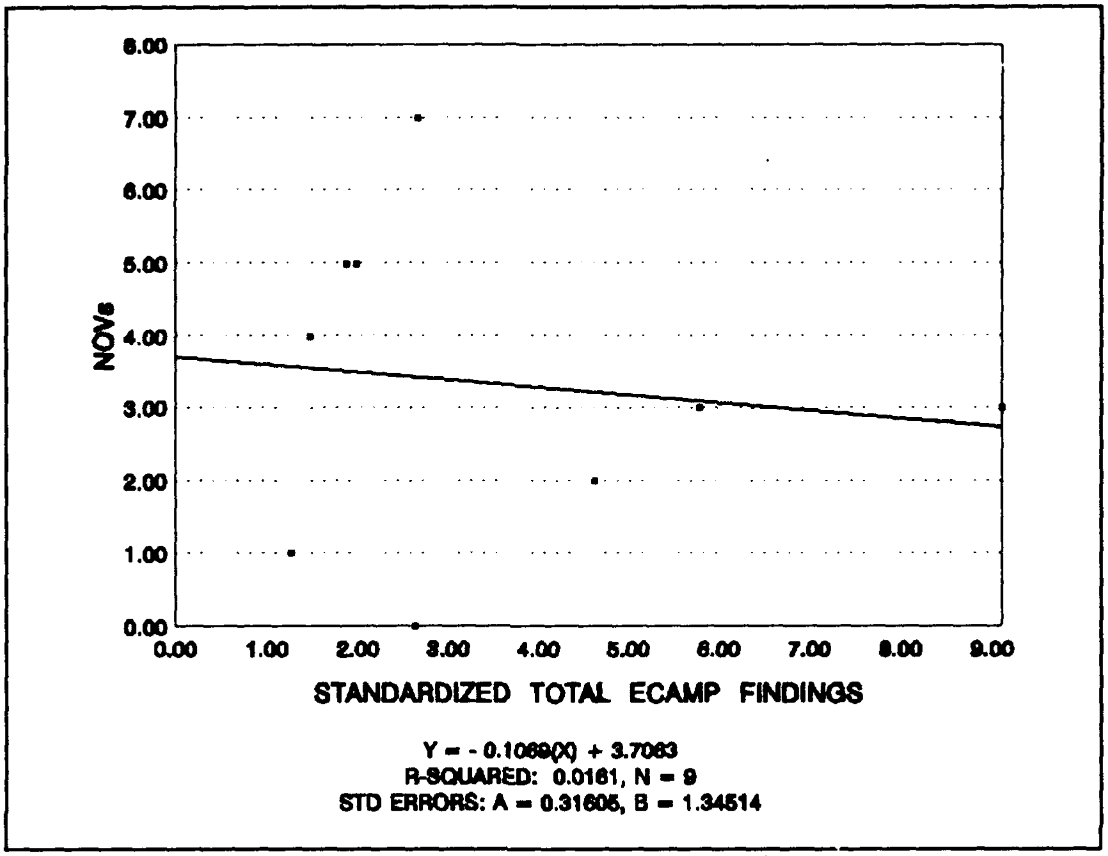

Figure 10. Regression Analysis, Total ECAMP Findings

The very low r^2 values of 0.0016 and 0.0161 seem to indicate that the number of NOVs is not dependent on the number of standardized ECAMP findings. However, five of the installations in the pilot study were former AF Logistics Command (AFLC) bases, two were former AF Systems Command (AFSC) bases, and one was previously a Military Airlift Command (MAC) installation. Since, as discussed in Chapter II, the BEE standardization factor is based on the AFMC specific BEE manpower determinant for the former AFLC bases and the standard BEE manpower determinant for the other three facilities, additional analyses were performed using only the data for the former AFLC installations. The results of these analyses are shown in Figures 11 and 12.

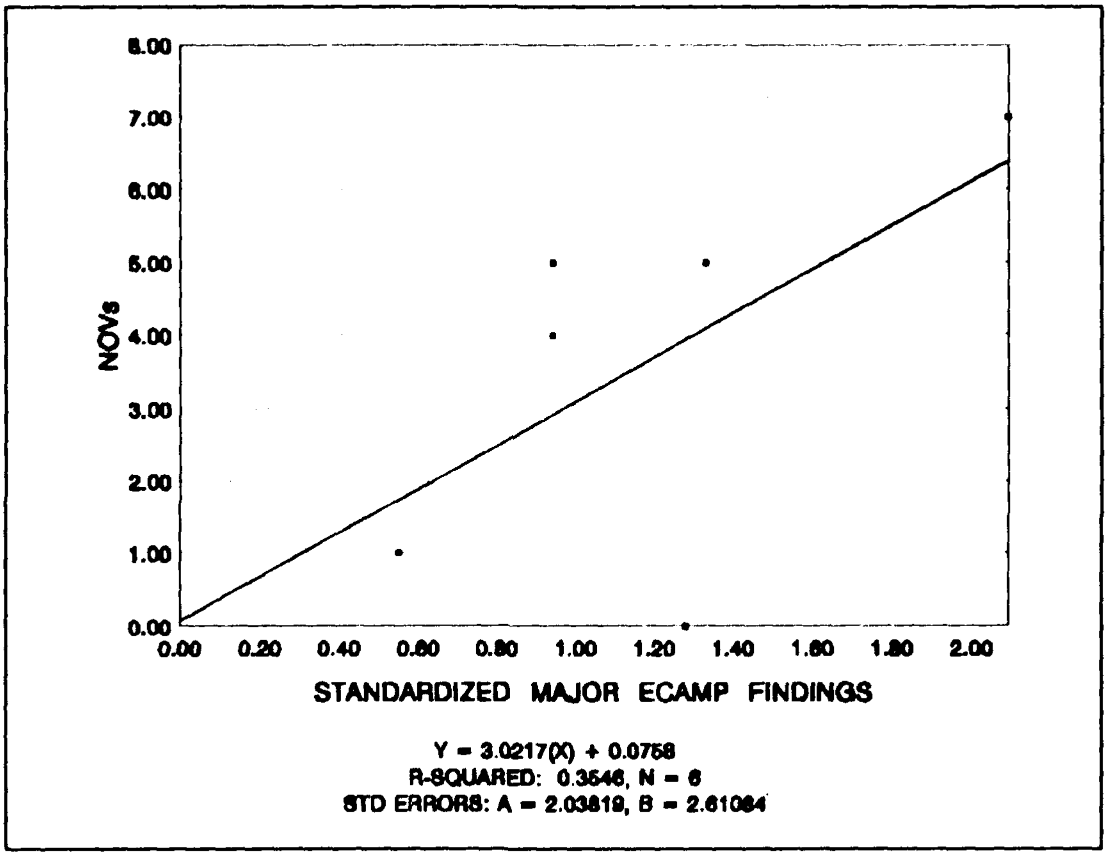

Figure 11. Regression Analysis, Major ECAMP Findings Former AFLCs Only

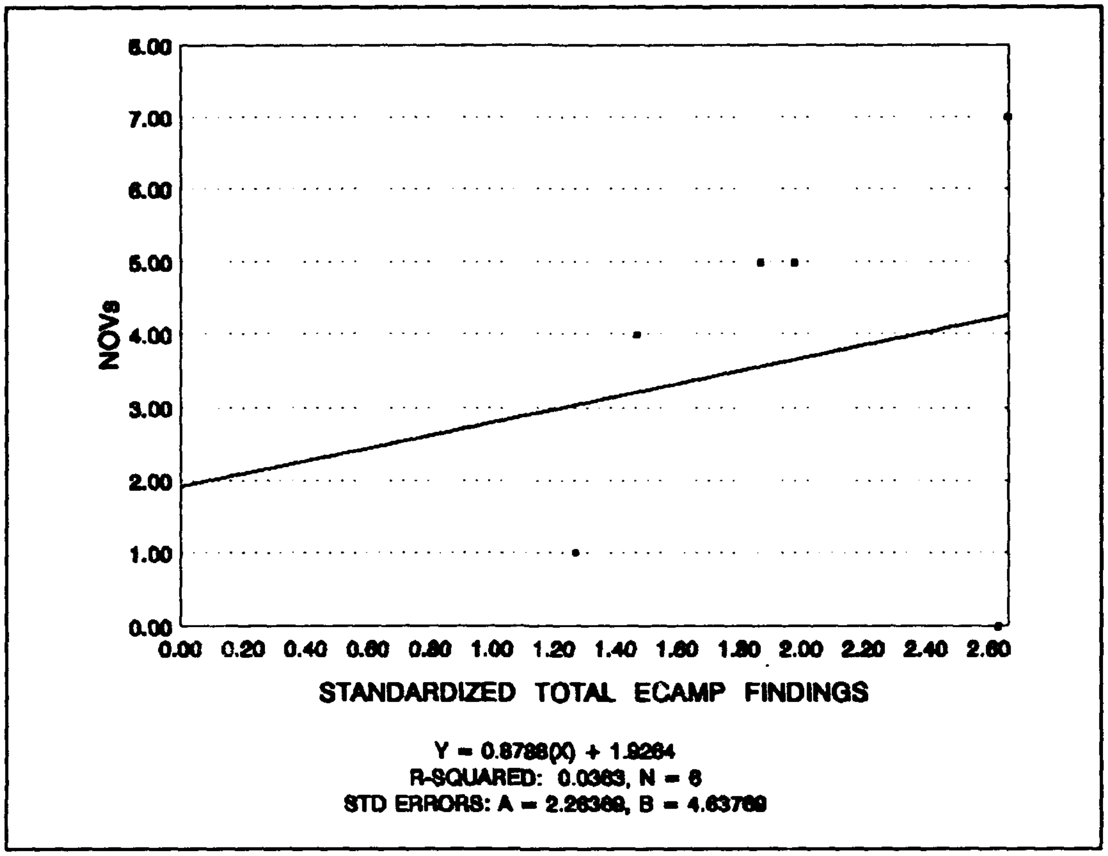

Figure 12. Regression Analysis, Total ECAMP Findings Former AFLCs Only

Once again, the very low r^2 values of 0.3546 and 0.0363 seem to indicate that the number of NOVs is not dependent on the number of standardized ECAMP findings. However, closer inspection of the two plots and the data in Table 9 reveals that although base AFMC-6 has 1.28 and 2.63 standardized ECAMP major and total findings respectively, it has no NOVs. This absence of NOVs appears unusual since other former AFLCs with similar numbers of standardized findings have from five to seven NOVs. In addition, a review of the NOV databases indicates that the other five former AFLCs have an average of 5.6 NOVs per installation from January 1991 through December 1992 while base AFMC-6 has no NOVs over the same time period. Furthermore, the other five installations have an average of 8.2 NOVs in the database while base AFMC-6 has only three. From a statistical perspective, the 95 percent confidence interval for NOVs at the six former AFLCs is 0.8769 to 6.4564. Thus, the absence of NOVs at base AFMC-6 appears to be anomalous and additional regression analyses were performed on the remaining former AFLC installations without the base AFMC-6 data. The results of these analyses are shown in Figures 13 and 14.

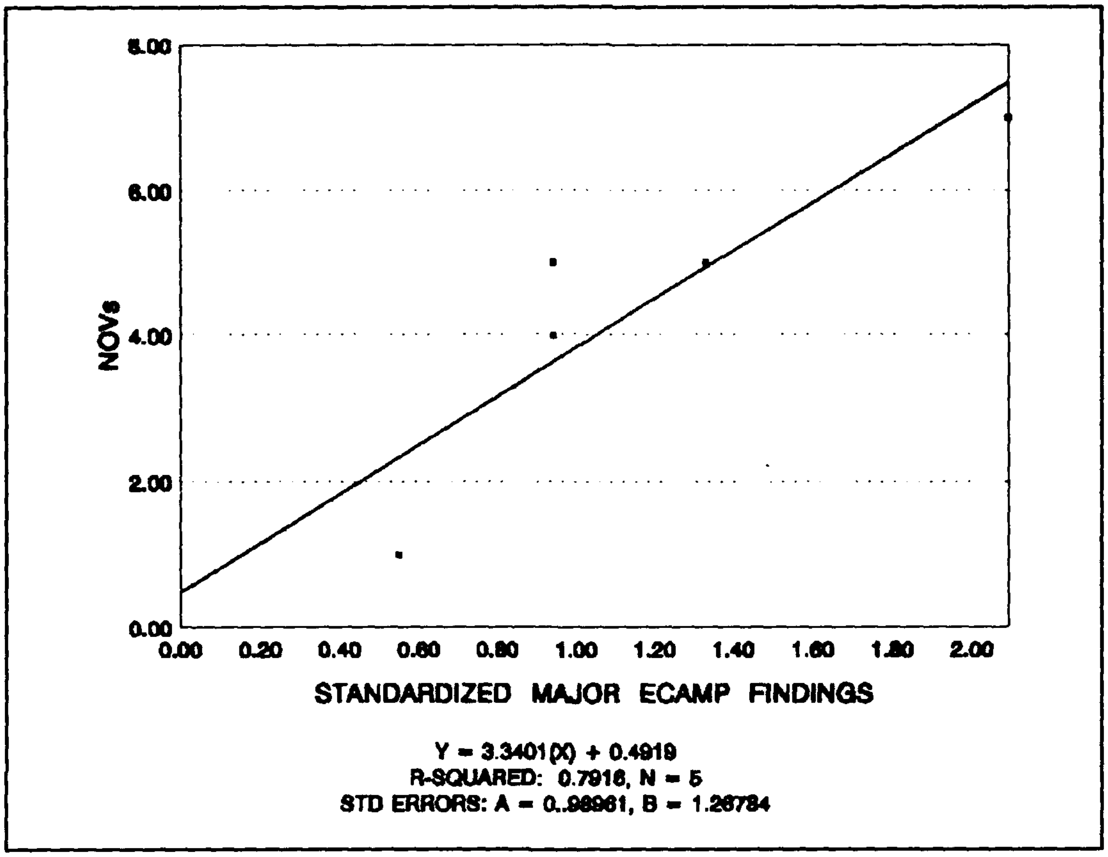

Figure 13. Regression Analysis, Major ECAMP Findings
Former AFLCs Without Base AFMC-6

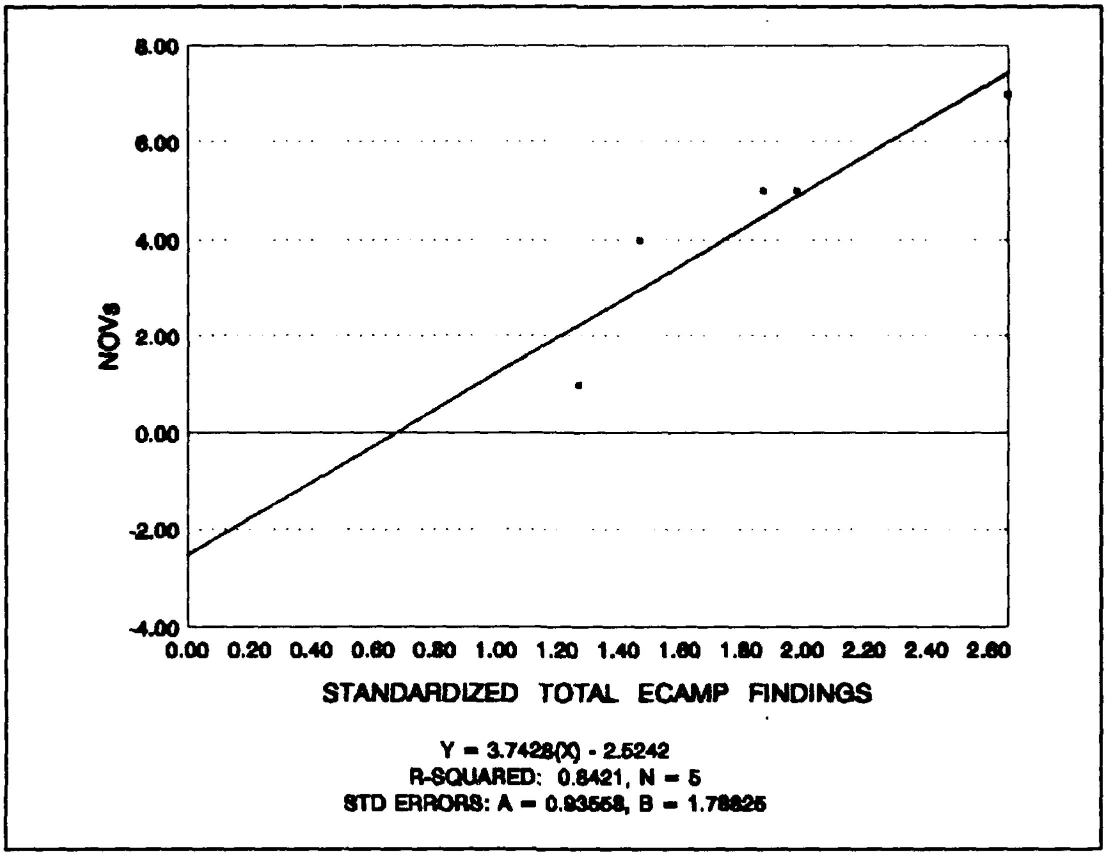

Figure 14. Regression Analysis, Total ECAMP Findings Former AFLCs Without Base AFMC-6

The vastly improved r^2 values of 0.7916 and 0.8421 suggest that approximately 80% of the variations in NOVs at these five installations can be explained by the variations in ECAMP findings standardized using BEE manpower authorizations. Similar analyses using unstandardized findings resulted in r^2 values of 0.7748 and 0.6011 for major and total ECAMP findings respectively. Thus, using standardized findings seems to result in somewhat better coefficients of determination. In general, the positive slope of both sets of regression lines indicates that as the number of standardized ECAMP findings increases, so does the number of NOVs. This positive correlation also suggests that although the ECAMP evaluations are accurately identifying compliance problems, the ECAMP findings are not being effectively used to identify the management actions necessary to prevent NOVs. Since the former AFLCs installations account for a substantial portion of the overall AFMC environmental budget, this correlation could be significant.

Summary. In contrast to the manpower authorization regression analyses which displayed a relatively strong relationship between BEE manpower and environmental manpower at the macro-level and weak relationship at the micro-level, the pilot study NOV regression analyses indicated a very weak relationship at the macro-level, for nine bases previously associated with three commands, and a strong relationship at the micro-level for five similar bases from the same command. Although the majority of the pilot study coefficients of determination were very low, the 0.79 and 0.84 r^2 values for the five former AFLC installations are potentially significant and clearly warrant followup. In addition, the possibility of similar relationships on a larger scale justifies expanding this study to installations in other commands.

Expanded Study

This section provides background information on the purpose of the expanded study, describes and discusses the results of twenty regression analyses performed to assess the relationships between NOVs and both standardized and unstandardized ECAMP findings on the macro- and micro-levels, introduces the proposed ECAMP Effectiveness Model, and summarizes the expanded study findings.

Background. The purpose of the expanded study was to investigate the relationships between NOVs and both standardized and unstandardized ECAMP findings on the macro- and micro- levels with installations from more than one major command. The specific objectives of this portion of the research were to determine if significant relationships exist between standardized and unstandardized ECAMP findings and NOVs on the macro-level for 35 installations from AFMC, ACC, and AMC and at the micro-level for 22 ACC and 4 AMC facilities. To assess these relationships, numerous regression analyses were performed using the ECAMP finding and NOV data in Appendix C. Overall, 22 ACC, 9 AFMC, and 4 AMC installations are represented in the data set. The standardization procedures used were the same as those outlined in the pilot study, and all regression analysis results describe the relationship between the number of NOVs (Y), and the number of standardized ECAMP findings (X).

Results. The regression analysis descriptions, numbers of datum points used, resulting r^2 values, and regression line equations for standardized ECAMP findings are presented in Table 10.

TABLE 10
EXPANDED STUDY REGRESSION ANALYSES RESULTS STANDARDIZED ECAMP FINDINGS

REGRESSION ANALYSIS DESCRIPTION	NUMBER DATA PTS	R^2 VALUES	REGRESSION LINE EQUATIONS
NOVs VS Std Major ECAMP Findings All Expanded Study Bases	35	0.0264	Y = - 0.195(X) + 2.473
NOVs VS Std Total ECAMP Findings All Expanded Study Bases	35	0.12[illegible]	Y = - 0.2355(X) + 3.243
NOVs VS Std Major ECAMP Findings ACC and AMC Bases Only	26	0.0096	Y = - 0.1044(X) + 1.745
NOVs VS Std Total ECAMP Findings ACC and AMC Bases Only	26	0.0406	Y = - 0.1527(X) + 2.399
NOVs VS Std Major ECAMP Findings ACC Bases Only	22	0.0029	Y = - 0.05[illegible]7(X) + 1.608
NOVs VS Std Total ECAMP Findings ACC Bases Only	22	0.0564	Y = - 0.1616(X) + 2.534
NOVs VS Std Major ECAMP Findings 1992 ECAMPs Only, ALL Commands	10	0.3356	Y = - 0.6690(X) + 5.096

TABLE 10

EXPANDED STUDY REGRESSION ANALYSES RESULTS STANDARDIZED ECAMP FINDINGS

REGRESSION ANALYSIS DESCRIPTION	NUMBER DATA PTS	R^2 VALUES	REGRESSION LINE EQUATIONS
NOVs VS Std Total ECAMP Findings 1992 ECAMPs Only, All Commands	10	0.4708	$Y = -0.4379(X) + 5.47$
NOVs VS Std Major ECAMP Findings 1991 ECAMPs Only, All Commands	14	0.0840	$Y = -0.2887(X) + 2.604$
NOVs VS Std Total ECAMP Findings 1991 ECAMPs Only, All Commands	14	0.1680	$Y = -0.2156(X) + 2.958$

As the r^2 values in Table 10 indicate, no significant relationships between NOVs and standardized ECAMP findings were identified at either the macro- or micro- levels in the expanded study. However, significant increases in r^2 values for the 1992 ECAMP evaluations over the r^2 values for the 1991 evaluations were noted, and in contrast to the pilot study, all the regression lines in Table 10 have negative slopes.

Since no significant relationships were identified using standardized ECAMP findings, similar regression analyses were performed using the unstandardized findings to determine if there was a significant difference in the relationships between standardized ECAMP findings and NOVs and unstandardized ECAMP findings and NOVs. These analyses were performed using the same ECAMP finding and NOV data that were used to produce the results in Table 10; however, the findings were not standardized. The results of these analyses are shown in Table 11.

TABLE 11

EXPANDED STUDY REGRESSION ANALYSES RESULTS
UNSTANDARDIZED ECAMP FINDINGS

REGRESSION ANALYSIS DESCRIPTION	NUMBER DATA PTS	R^2 VALUES	REGRESSION LINE EQUATIONS
NOVs VS Unstd Major ECAMP Findings All Expanded Study Bases	35	0.1125	Y = 0.03(X) + 0.8760
NOVs VS Unstd Total ECAMP Findings All Expanded Study Bases	35	0.0356	Y = 0.0129(X) + 1.089
NOVs VS Unstd Major ECAMP Findings ACC and AMC Bases Only	26	0.0023	Y = 5.8E-03(X) + 1.270
NOVs VS Unstd Total ECAMP Findings ACC and AMC Bases Only	26	0.0066	Y = - 6.3E-03(X) + 1.75
NOVs VS Unstd Major ECAMP Findings ACC Bases Only	22	0.0056	Y = 9.1E-03(X) + 1.106
NOVs VS Unstd Total ECAMP Findings ACC Bases Only	22	0.0048	Y = - 5.4E-03(X) + 1.68

TABLE 11

EXPANDED STUDY REGRESSION ANALYSES RESULTS
UNSTANDARDIZED ECAMP FINDINGS

REGRESSION ANALYSIS DESCRIPTION	NUMBER DATA PTS	R^2 VALUES	REGRESSION LINE EQUATIONS
NOVs VS Unstd Major ECAMP Findings 1992 ECAMPs Only, All Commands	10	0.0700	Y = 0.022(X) + 1.5257
NOVs VS Unstd Total ECAMP Findings 1992 ECAMPs Only, All Commands	10	0.0157	Y = 8.86E-03(X) + 1.92
NOVs VS Unstd Major ECAMP Findings 1991 ECAMPs Only, All Commands	14	0.0893	Y = 0.0337(X) + 0.5277
NOVs VS Unstd Total ECAMP Findings 1991 ECAMPs Only, All Commands	14	0.0030	Y = 4.3E-03(X) + 1.4404

Once again, no significant relationships between NOVs and unstandardized ECAMP findings were identified at either the macro- or micro- levels. Overall, seven of ten r^2

values were higher with standardized findings than with unstandardized findings. In addition, the significant increases in r^2 values for the 1992 data that were present using standardized findings were absent when unstandardized findings were used. The most notable difference however, was the change in slope of the regression lines.

All ten regression lines were negatively sloped when standardized ECAMP findings were used while seven of ten regression lines were positively sloped with unstandardized ECAMP findings. At first, this difference in slopes appears significant since the slope of the regression line should reflect overall ECAMP effectiveness. Negatives slopes would suggest that as the number of ECAMP findings increases, the number of NOVs decreases, and positive slopes indicate that as the number of ECAMP findings increases, the number of NOVs also increases. An effective ECAMP should be characterized by a negative slope while a positive slope would be indicative of an ineffective ECAMP. However, the slopes of all twenty regression lines are between -0.669 and 0.0337 so the difference in slope is not as significant as it first appeared. In addition, the low r^2 values for all twenty analyses make it unrealistic to draw conclusions about ECAMP effectiveness from these results.

Although no metrics for measuring ECAMP effectiveness that use either standardized or unstandardized ECAMP findings and historical NOVs are currently available, closer inspection of the scatter plot for all the data in the expanded study, Figure 15, resulted in a theoretical framework for the development of such a ECAMP Effectiveness Model or metric.

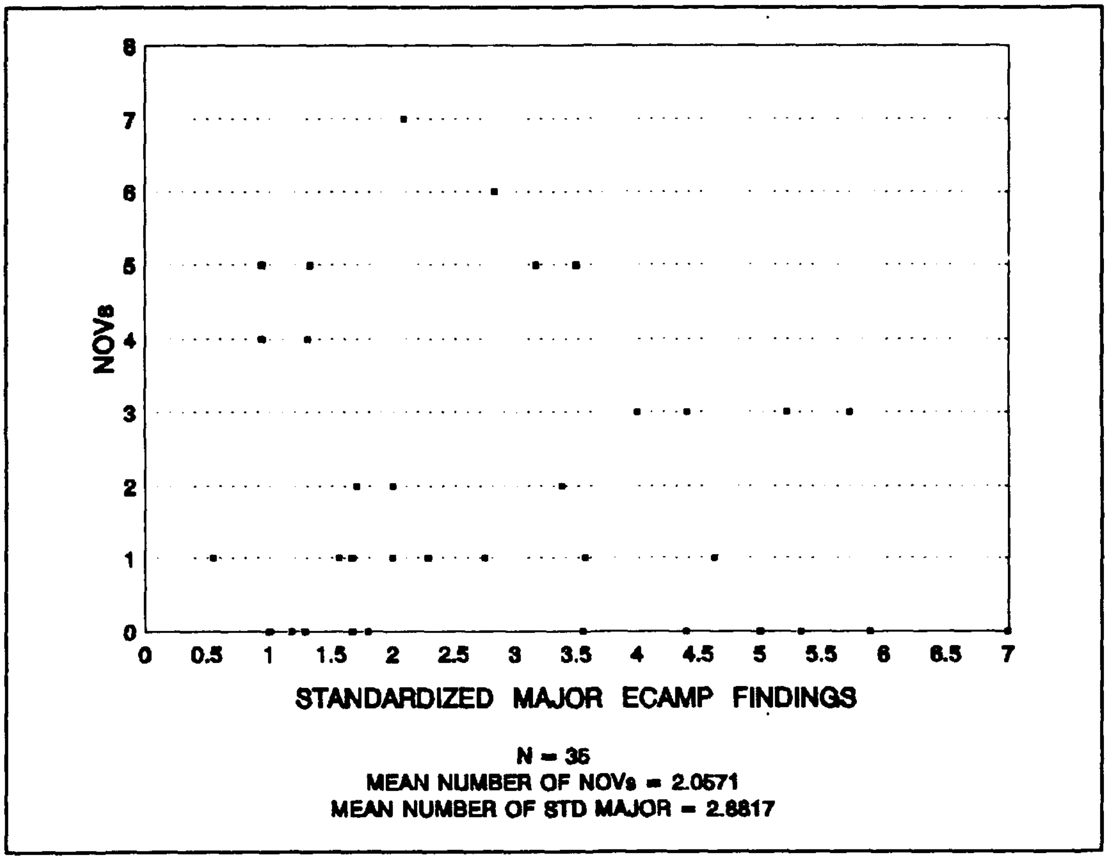

Figure 15. Scatter Plot, All Expanded Study Data

In general, the proposed ECAMP Effectiveness Model or metric involves dividing the scatter plot into four quadrants by plotting the lines for the average number of NOVs and standardized ECAMP findings. In this case, the four quadrants are constructed by plotting the lines Y = 2.0571 and X = 2.8817 as shown in figure 16.

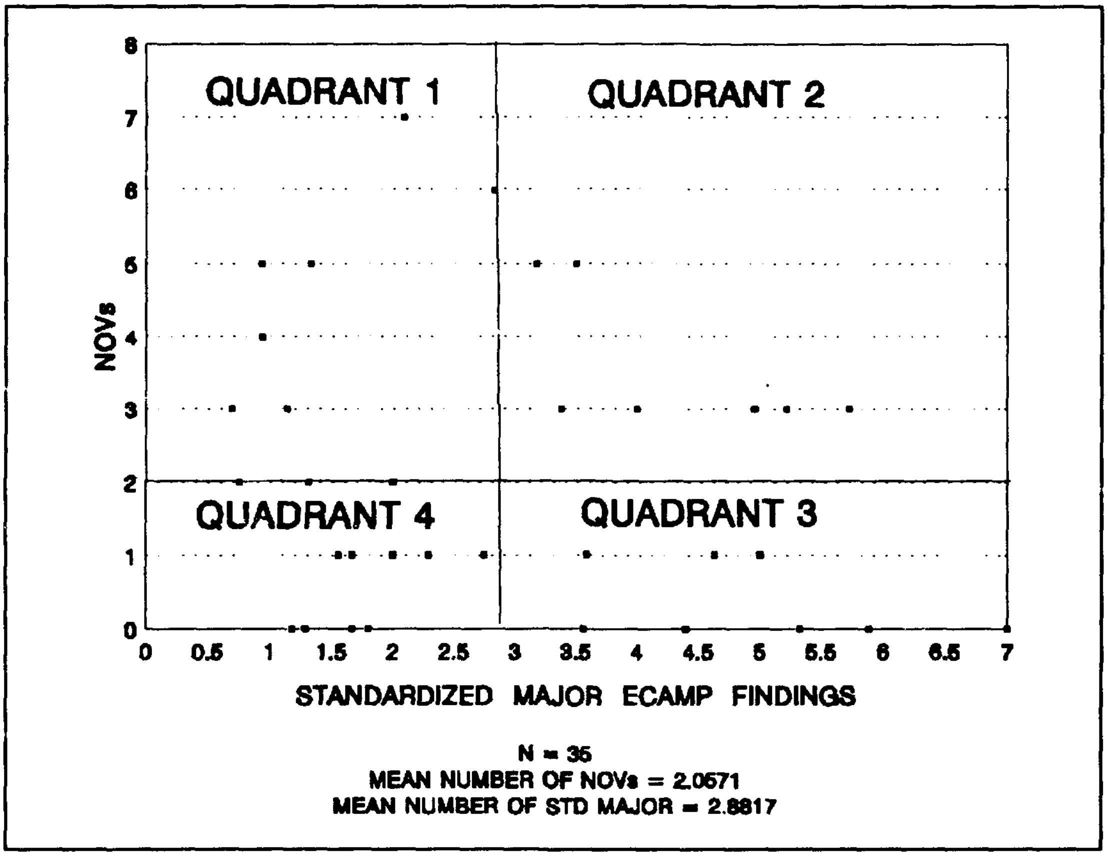

Figure 16. ECAMP Effectiveness Model Quadrants

This four quadrant approach to ECAMP effectiveness is patterned after the two-factor theory of leadership developed by Fleishman and his associates at Ohio State University (OSU) in the 1950s (26:375). In the OSU studies, the two leadership effectiveness factors of initiating structure (Y) and consideration (X) were assessed using questionnaires and plotted with the premise that a high degree of consideration and a high degree of initiating structure (High-High or Quadrant 2) was best (26:375-376). Similarly, the proposed model assesses and plots the two ECAMP effectiveness factors of NOVs (Y) and standardized ECAMP findings (X) with the premise that fewer NOVs and fewer standardized ECAMP, (Low-Low or Quadrant 4) are best. Although the expanded study did not yield significant coefficients of determination, the proposed ECAMP Effectiveness Model could be used to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance.

Summary. In contrast to the pilot study, no significant relationships between NOVs and standardized or unstandardized ECAMP findings were identified at either the macro- or micro- levels in the expanded study. However, a detailed review of the expanded study data did result in a theoretical framework for a proposed ECAMP Effectiveness Model or metric. The proposed model is patterned after the two-factor theory of leadership, and the model is based on the premise that fewer NOVs and fewer ECAMP findings are best. This premise is based on logic which is described in greater detail in the next section on the proposed ECAMP Effectiveness Model.

Proposed ECAMP Effectiveness Model

This section provides background information on ECAMP effectiveness and a theoretical ECAMP maturation process, describes the use of the proposed ECAMP Effectiveness Model, discusses model results, summarizes model findings, and concludes that implementing the proposed model could assist AF decision-makers in ensuring that scarce resources are properly allocated and apportioned among installations with competing environmental compliance requirements.

Background. In general, an effective ECAMP program should be characterized by a negative correlation between NOVs and standardized ECAMP findings. In other words, as the number of standardized ECAMP findings increases, more compliance problems are identified, corrected, and prevented so the number of NOVs should decrease. Theoretically, a perfectly effective and properly administered environmental auditing program such as ECAMP should result in progressively fewer ECAMP findings and ultimately a gradual reduction in the number of NOVs as all potential compliance problems are identified, corrected, and subsequently prevented.

ECAMP should evolve and mature over time. Since ECAMP is a decentralized program, the maturation process may vary between commands and from one installation to the next. In addition, other factors such as manpower shortages and changes in environmental regulatory requirements may cause

ECAMP effectiveness to fluctuate between effectiveness quadrants with fewer ECAMP findings and NOVs indicating an effective ECAMP. In theory however, the ECAMP maturation process would be expected to progress through four distinct phases. Installations in phase I of the ECAMP evolutionary process will be distinguished by more NOVs and fewer standardized ECAMP findings than expected since the program is immature and base personnel are inexperienced. As the ECAMP matures and personnel become more familiar with identifying compliance problems, the program should progress to phase II which will be characterized by both more NOVs and ECAMP findings. In phase III of the ECAMP maturation process, installation personnel become more adept at correcting ECAMP findings before NOVs occur, and installations in this phase will be identified by fewer NOVs and more ECAMP findings then expected. Finally, in phase IV of the hypothetical ECAMP maturation process the program is effectively identifying, correcting, and preventing compliance problems. As a result, installations in phase IV will be recognized by both fewer NOVs and fewer ECAMP findings. The four phases described above also correspond to the four quadrants as depicted in Figure 17.

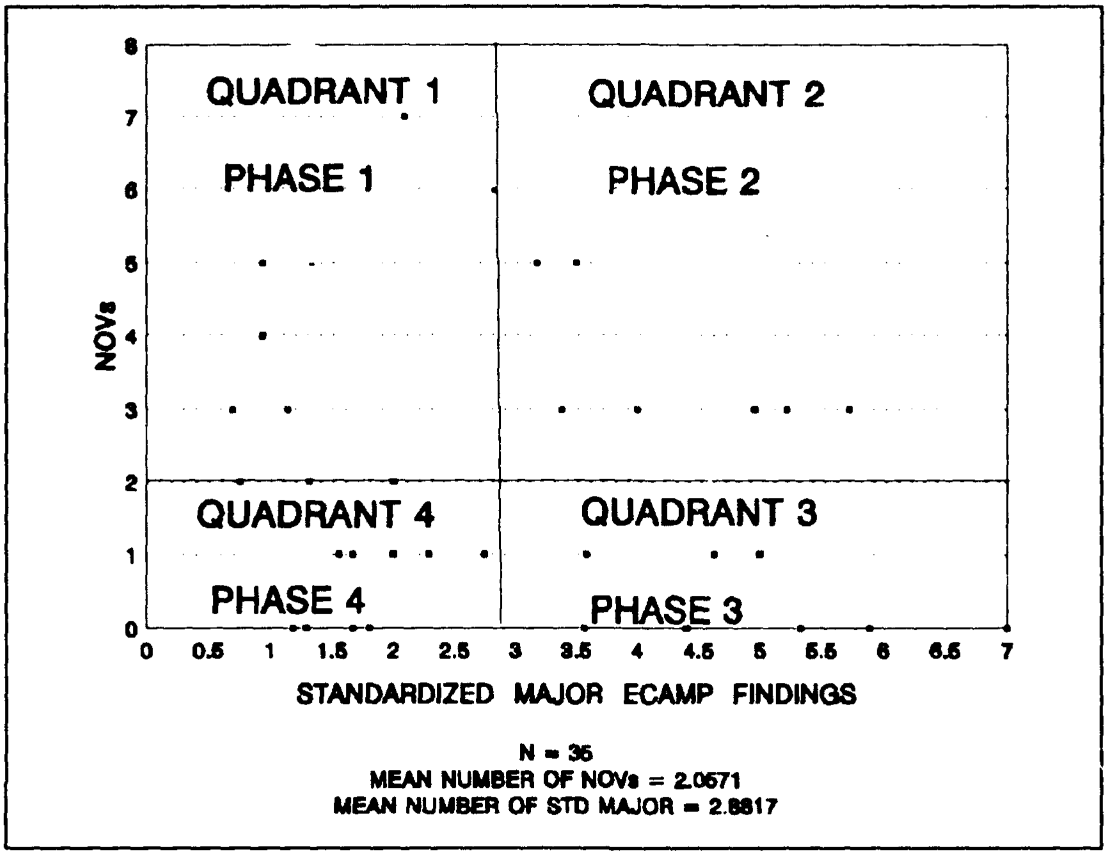

Figure 17. ECAMP Effectiveness Model Quadrants and Phases

Since the phase or quadrant boundaries are determined by the user, simply plotting NOVs against standardized ECAMP findings and drawing lines representing AF or command averages will provide the AF decision-maker with a quick visual indication of an installation's relative ECAMP effectiveness. In addition, the proposed model is very flexible, and it can be used both prospectively and retrospectively by plotting NOVs prior to and following any ECAMP evaluation. The use of the proposed ECAMP

Effectiveness Model is described in the results section that follows.

Results. In order to obtain relative ECAMP effectiveness results from the proposed model, the first step was to determine the average numbers of NOVs and standardized ECAMP findings which would be plotted on the scatter diagram to define the four phases or ECAMP effectiveness quadrants. To ensure that the values used in the model were realistic, the historical NOV data for the 12 AFMC, 34 ACC, and 13 AMC installations used in this study were compiled as shown in Appendix D. Similarly, the ECAMP finding data for the same installations were organized as shown in Appendix E. This information was then used to calculate the average numbers of NOVs and standardized ECAMP findings. These results and other pertinent descriptive statistics are displayed in Tables 12 and 13.

TABLE 12

NOV DATA DESCRIPTIVE STATISTICS

DESCRIPTIVE STATISTICS	NOVs 1989	NOVs 1990	NOVs 1991	NOVs 1992
DATA POINTS	59	59	59	59
LOWER 95% C.I.	0.2023	0.6789	1.0363	1.2347
MEAN	0.3898	0.9830	1.5423	1.6610
UPPER 95% C.I.	0.5773	1.2871	2.0483	2.0873
STD DEVIATION	0.7196	1.1669	1.9415	1.6359
MINIMUM	0.0	0.0	0.0	0.0
MEDIAN	0.0	1.0	1.0	1.0
MAXIMUM	3.0	5.0	8.0	7.0

TABLE 13

ECAMP DATA DESCRIPTIVE STATISTICS

DESCRIPTIVE STATISTICS	STD MAJOR FINDINGS ALL	STD TOTAL FINDINGS ALL	STD MAJOR FINDINGS 1991-93	STD TOTAL FINDINGS 1991-93
DATA POINTS	58	58	47	47
LOWER 95% C.I.	3.6198	6.8306	4.0944	7.3825
MEAN	4.3839	8.1439	4.9561	8.9148
UPPER 95% C.I.	5.1480	9.4573	5.8179	10.447
STD DEVIATION	2.9059	4.9949	2.9349	5.2188
MINIMUM	0.69	1.47	0.69	1.47
MEDIAN	4.0	7.55	4.92	8.63
MAXIMUM	12.4	20.13	12.4	20.13

Based on these results, the average numbers of historical NOVs and standardized ECAMP findings used in the model were 1.6, 5, and 9 for NOVs, standardized major, and standardized total findings respectively.

Next, the bases in the data set with ECAMP evaluations in 1991 or 1992 and with NOV data for both 1-year prior to and 1-year after the evaluation were identified. The NOV and ECAMP data for the 24 bases meeting these requirements are listed in Appendix F. This information was then combined with the average numbers of NOVs and standardized ECAMP findings to produce the ECAMP Effectiveness Model scatter plots in Figures 18-21.

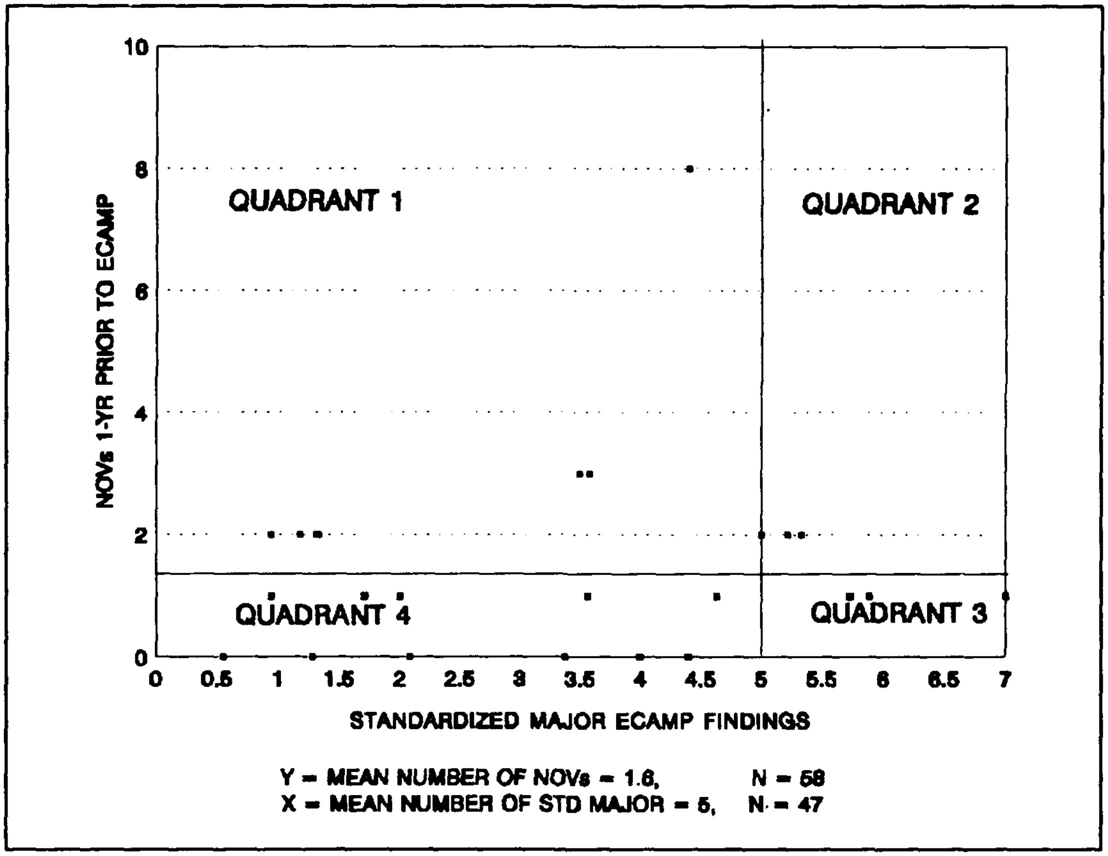

Figure 18. ECAMP Effectiveness Model, NOVs 1-Year Prior Versus Standardized Major Findings

Figure 18 displays relative ECAMP effectiveness by plotting NOVs 1-year prior to the ECAMP evaluation against standardized major ECAMP findings. Of the 24 bases shown on the plot, seven fall in quadrant 1, three in quadrant 2, three in quadrant 3, and eleven in quadrant 4. Overall, the 10 bases in quadrants 1 and 2 received more NOVs than the a· ,rage of 1.6 in the 1-year immediately prior to the ECAMP evaluation while the 14 bases in quadrants 3 and 4 received fewer NOVs than average over the same time. Similarly, the 17 bases in quadrants 1 and 4 had fewer major ECAMP findings than average while the 7 bases in quadrants 2 and 3 received more than the average of 5.

Figure 19 plots the NOVs 1-year prior to the same evaluation against the standardized total ECAMP findings.

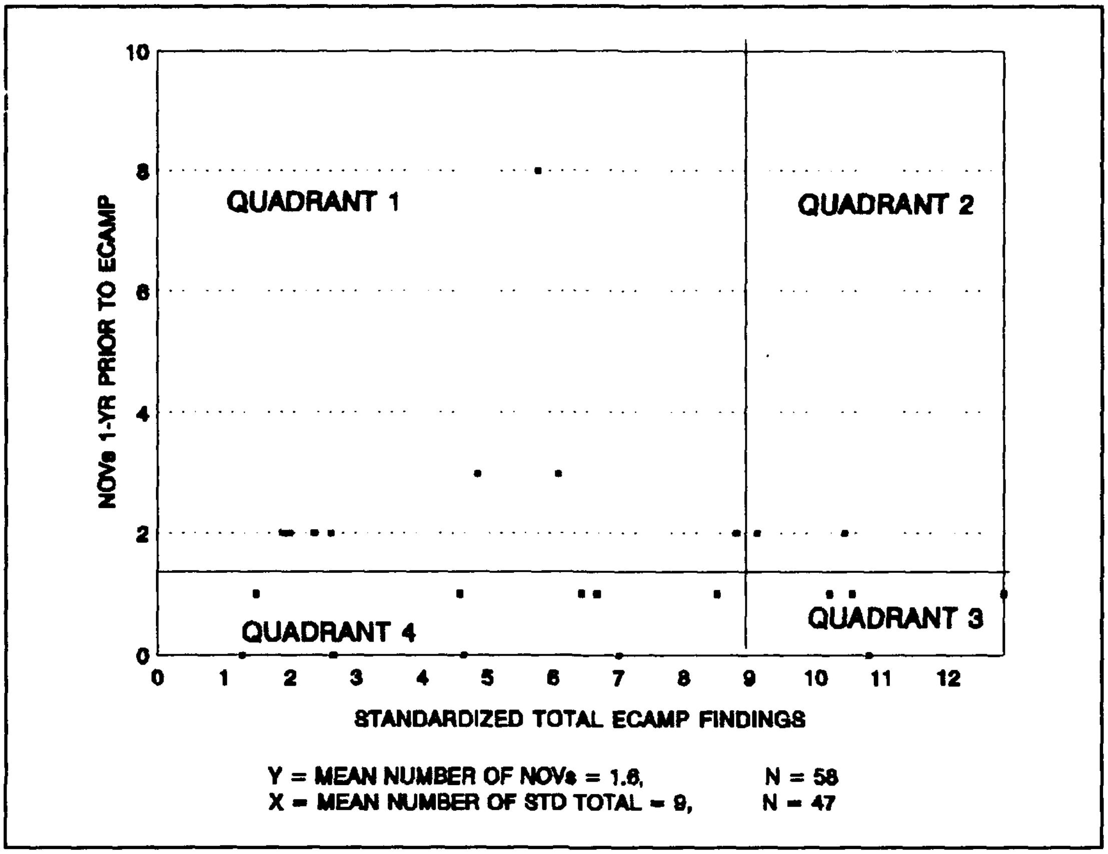

Figure 19. ECAMP Effectiveness Model, NOVs 1-Year Prior Versus Standardized Total Findings

This plot shows eight bases in quadrant 1, two in quadrant 2, four in quadrant 3, and ten in quadrant 4. These findings are very similar to those plotted in Figure 17, and the number of installations falling into quadrants 1 and 2, and 3 and 4 are identical. These similarities seem to indicate that both standardized major and standardized total findings provide similar information about ECAMP effectiveness. However, plotting both standardized major and total findings could provide additional insight into which direction an installation's program is progressing in the ECAMP maturation process.

To investigate this possibility, the same standardized major and total findings were plotted against NOVs 1-year after the ECAMP evaluation. The number of NOVs 1-year after the ECAMP evaluations are plotted against standardized major ECAMP findings in Figure 20.

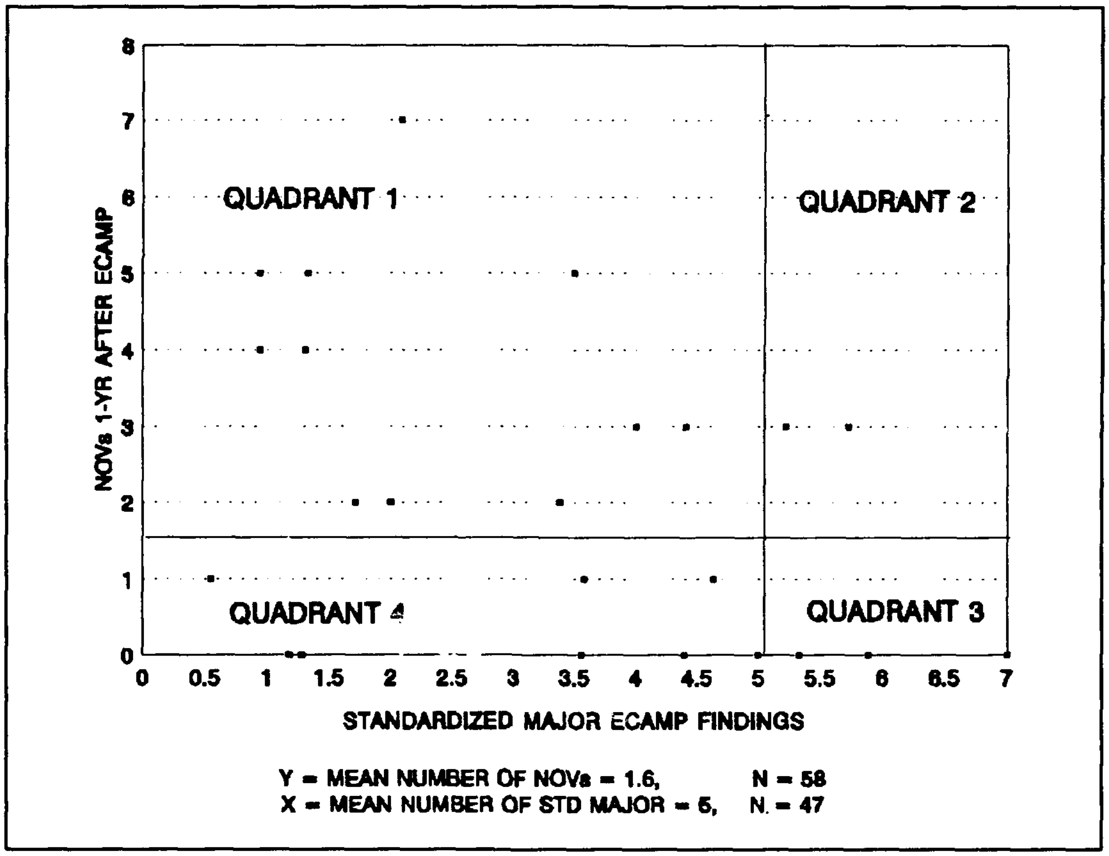

Figure 20. ECAMP Effectiveness Model, NOVs 1-Year After Versus Standardized Major Findings

The scatter plot in Figure 20 shows eleven bases in quadrant 1, two in quadrant 2, three in quadrant 3, and eight in quadrant 4. This is a significant change from Figure 18 where seven, three, three, and eleven bases were in quadrants 1-4 respectively. To see if total findings reveal similar changes, NOVs 1-year after the ECAMP evaluations are plotted against standardized total findings in Figure 21.

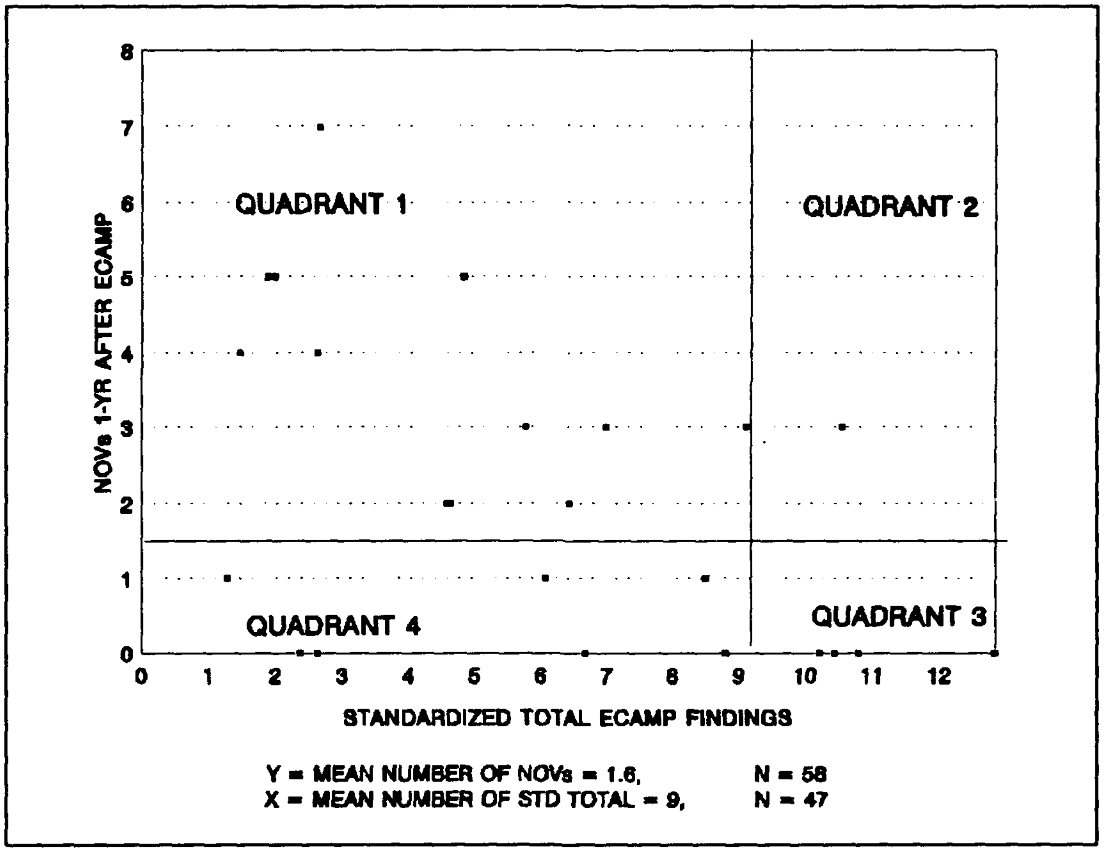

Figure 21. ECAMP Effectiveness Model, NOVs 1-Year After Versus Standardized Total Findings

Figure 21 is very similar to Figure 20 with eleven, two, four, and eight bases in quadrants 1-4 respectively.

Overall, thirteen bases received more NOVs 1-year after these ECAMP evaluations than average. This number is up from the ten installations which received more NOVs than average 1-year prior to the same evaluations. In general, this indicates a decrease in ECAMP effectiveness which parallels the increasing number of NOVs that the AF is receiving.

To assist AF decision-makers in reducing the number of NOVs, the proposed ECAMP Effectiveness Model must provide information identifying both installations with effective ECAMP programs and those where programs need more attention or resources to prevent future environmental problems and improve environmental compliance. To demonstrate how the proposed model can be used to provide decision-makers with this information, the data in Figures 18-21 are presented and analyzed by installation in Table 14.

TABLE 14

ECAMP EFFECTIVENESS MODEL DATA ANALYSIS FIGURES 18-21

BASE	QUAD. 1-YR PRIOR FIG 18	QUAD. 1-YR PRIOR FIG 19	QUAD. AFTER 1-YR FIG 20	QUAD. AFTER 1-YR FIG 21	EFFECT TREND	OVERALL RATINGS
AFMC-1	2	2	2	2	NO CHANGE	MARG/MARG
AFMC-3	4	4	4	4	NO CHANGE	EXCEL/EXCEL
AFMC-4	1	1	1	1	NO CHANGE	UNSAT/UNSAT
AFMC-5	4	4	1	1	DECREASE	EXCEL/UNSAT
AFMC-6	4	4	4	4	NO CHANGE	EXCEL/EXCEL
AFMC-7	4	4	1	1	DECREASE	EXCEL/UNSAT
AFMC-9	1	1	1	1	NO CHANGE	UNSAT/UNSAT
AFMC-10	1	1	1	1	NO CHANGE	UNSAT/UNSAT
AFMC-12	4	4	1	1	DECREASE	EXCEL/UNSAT
ACC-3	1	1	1	1	NO CHANGE	UNSAT/UNSAT
ACC-4	1	1	4	4	INCREASE	UNSAT/EXCEL
ACC-5	2	1	3-4	4	INCREASE	MARG/EXCEL
ACC-6	4	4	1	1	DECREASE	EXCEL/UNSAT
ACC-8	2	2	3	3	INCREASE	MARG/SAT
ACC-10	4	3	4	3	NO CHANGE	EXCEL/EXCEL
ACC-18	3	3	3	3	NO CHANGE	SAT/SAT

TABLE 14

ECAMP EFFECTIVENESS DATA ANALYSIS FIGURE 18-21

(1) BASE	QUAD. 1-YR PRIOR FIG 18	QUAD. 1-YR PRIOR FIG 19	QUAD. AFTER 1-YR FIG 20	QUAD. AFTER 1-YR FIG 21	EFFECT TREND	OVERALL RATINGS
ACC-24	4	4	4	4	NO CHANGE	EXCEL/EXCEL
ACC-28	4	4	1	1	DECREASE	EXCEL/UNSAT
ACC-31	3	3	3	3	NO CHANGE	SAT/SAT
ACC-32	4	4	4	4	NO CHANGE	EXCEL/EXCEL
ACC-33	3	3	2	2	DECREASE	SAT/MARG
AMC-1	1	1	1	1	NO CHANGE	UNSAT/UNSAT
AMC-9	4	4	1	1	DECREASE	EXCEL/UNSAT
AMC-10	1	1	4	4	INCREASE	UNSAT/EXCEL

As anticipated, Table 14 indicates that ECAMP effectiveness like environmental compliance is dynamic and changing. Overall, eleven of the 24 bases analyzed in the table displayed changes in ECAMP effectiveness with seven installations exhibiting effectiveness decreases and four showing ECAMP effectiveness increases over the two year period. By assigning standard AF ratings of unsatisfactory, marginal, satisfactory, and excellent to quadrants 1-4 respectively, it is also possible to determine overall ECAMP effectiveness ratings for each installation during the two, 1-year periods. By using this rating system, five installations were identified with consistently unsatisfactory or ineffective ECAMP programs, six other programs have decreased in effectiveness from excellent to unsatisfactory, and two additional programs were rated as marginal. In effect, analyzing the ECAMP Effectiveness Model data in Figures 18-21 using the tabular format and rating system described above clearly identifies the installations with effective and ineffective ECAMP programs. Moreover, the proposed model is extremely flexible, and it can be easily adapted to reflect changes in AF or MAJCOM averages or goals.

To demonstrate the flexibility of the proposed model and provide additional insight into the effects and potential benefits of standardizing ECAMP findings using BEE manpower authorizations, the NOV and ECAMP data for the same 24 bases was analyzed again using unstandardized ECAMP findings. The actual data used in the analyses is provided in Appendix G, and Figure 22 displays relative ECAMP effectiveness by plotting NOVs 1-year prior to the ECAMP evaluation against unstandardized major ECAMP findings.

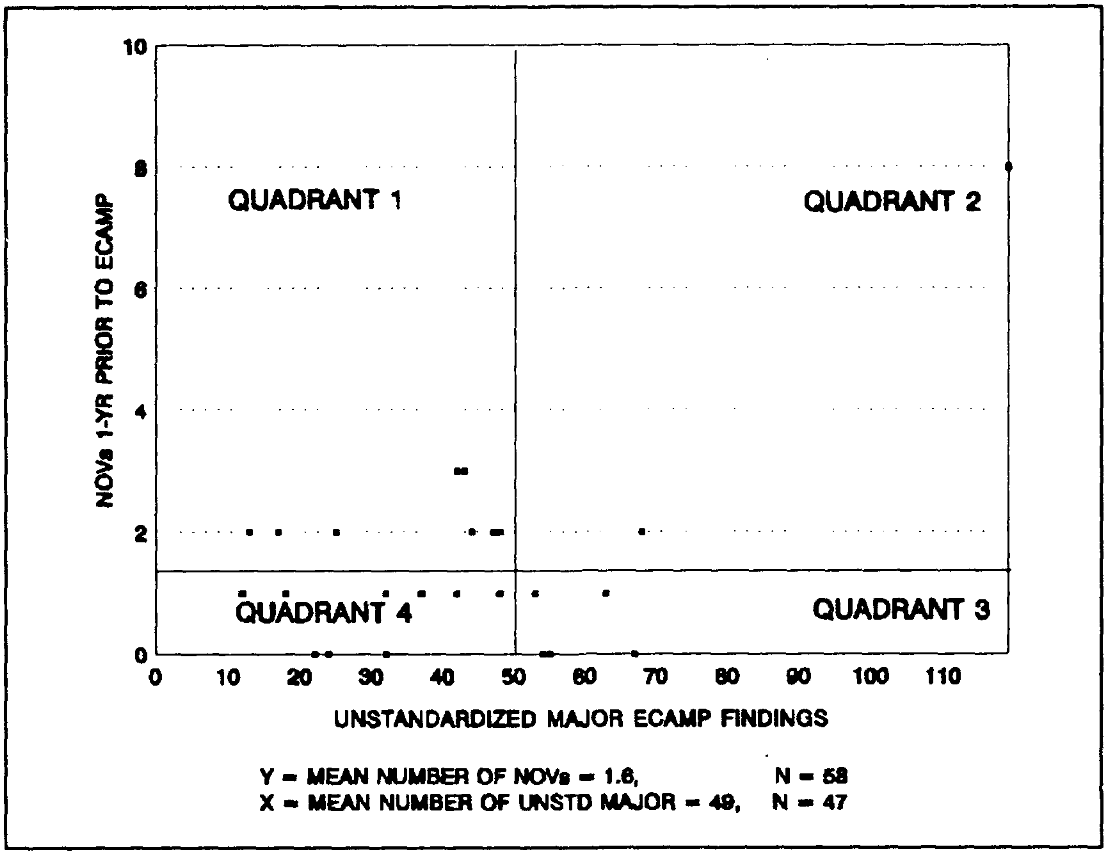

Figure 22. ECAMP Effectiveness Model, NOVs 1-Year Prior Versus Unstandardized Major Findings

In effect, Figure 22 uses exactly the same data as Figure 18 except, the ECAMP findings were not standardized using BEE manpower authorizations, and the mean numbers of unstandardized major and total ECAMP findings were used to define the quadrants. Eight of the twenty-four bases plotted in Figure 22 fall in quadrant 1, two in quadrant 2, five in quadrant 3, and nine in quadrant 4. This compares with seven, three, three, and eleven bases in quadrants 1-4 respectively when standardized findings were used. Since the number of NOVs plotted for each base remained the same, it was not possible for a base to move from quadrants 1 or 2 to quadrants 3 or 4 and vice versa. However, shifts between quadrants 1 and 2 or between quadrants 3 and 4 were possible. In this instance, Figure 22 indicates that using unstandardized findings caused one base to move from quadrant 2 to quadrant 1 while two bases shifted from quadrant 4 to quadrant 3. In all three cases, theses shifts indicate a relative decrease in ECAMP effectiveness.

Similarly, Figure 23 plots the NOVs 1-year prior to the same evaluation against the unstandardized total ECAMP findings.

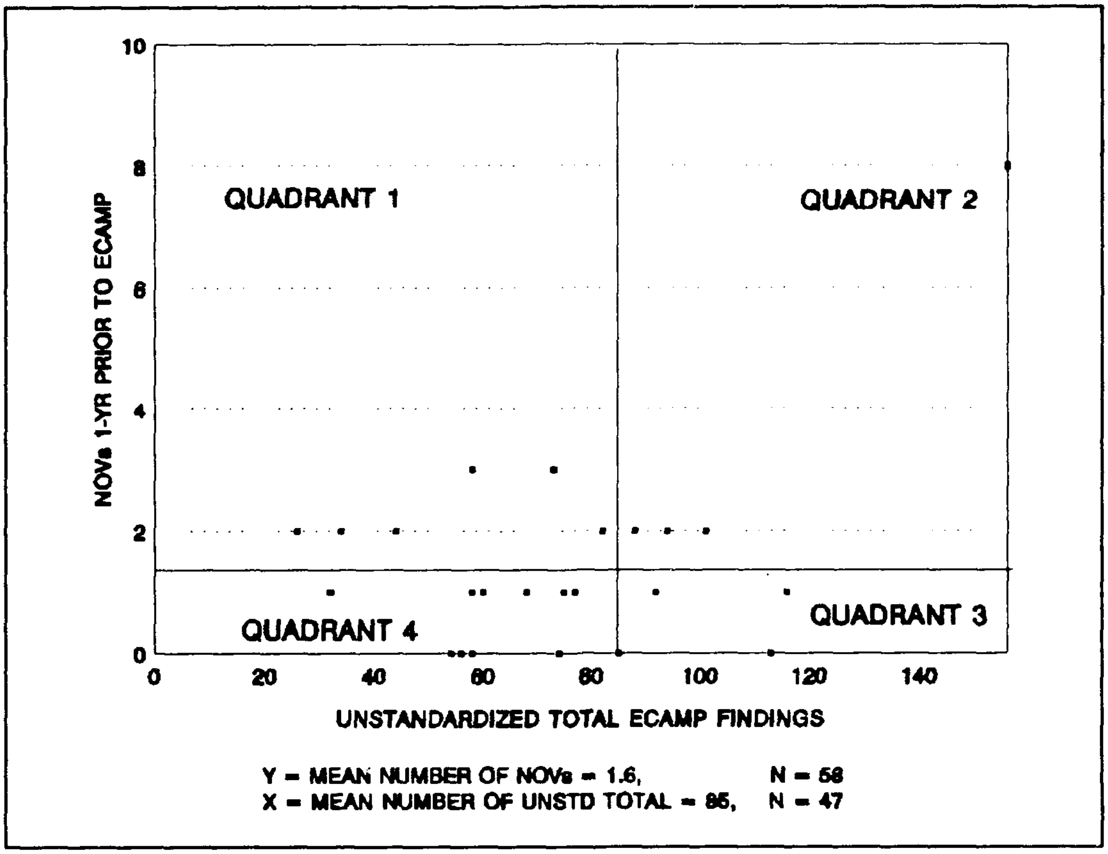

Figure 23. ECAMP Effectiveness Model, NOVs 1-Year Prior Versus Unstandardized Total Findings

This figure shows six, four, four, and ten bases in quadrants 1-4 respectively. Comparing these results to the corresponding standardized findings previously depicted in Figure 19 reveals that two bases moved from quadrant 1 to quadrant 2 when unstandardized findings were used. In contrast to the differences just described between Figures 18 and 22, the shifts between Figures 19 and 23 indicate relative ECAMP effectiveness increases.

To further investigate the differences in overall model effectiveness ratings between standardized and unstandardized findings, the same unstandardized major and total findings were plotted against NOVs 1-year after the ECAMP evaluations. Figures 24 and 25 plot the number of NOVs 1-year after the ECAMP evaluation against unstandardized major and total ECAMP findings respectively.

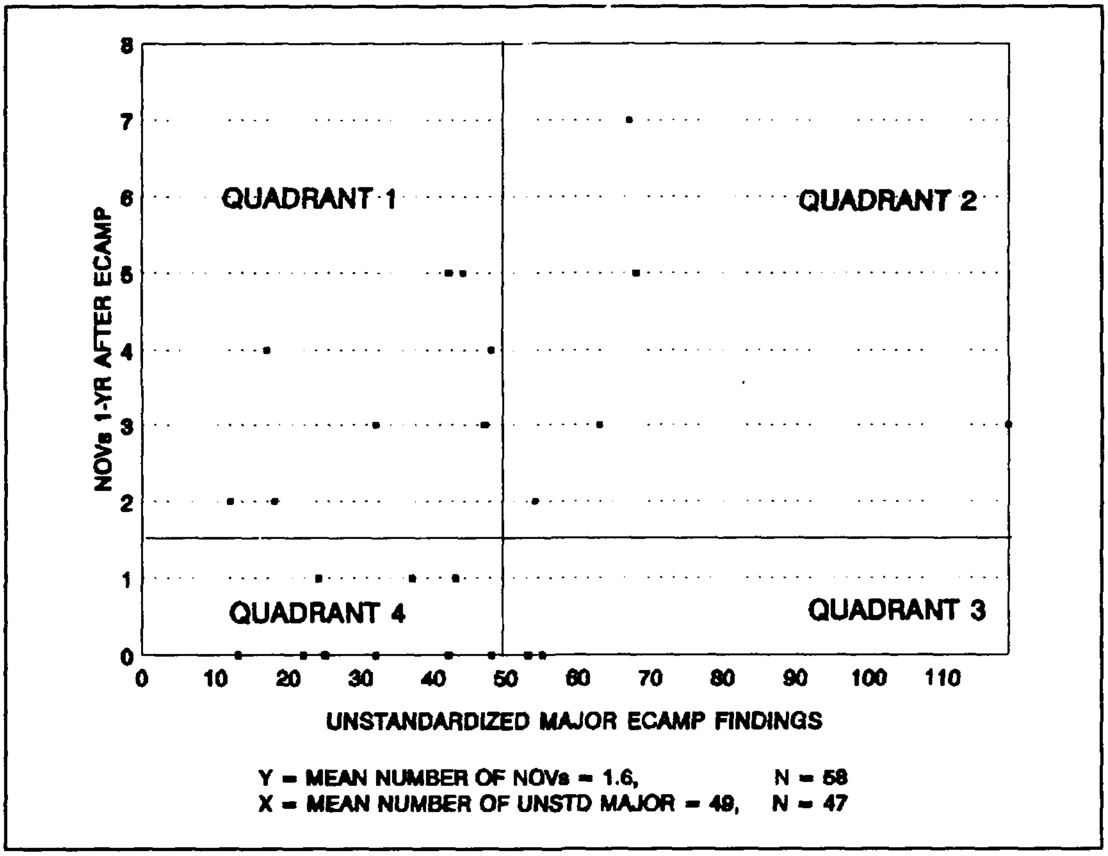

Figure 24. ECAMP Effectiveness Model, NOVs 1-Year After Versus Unstandardized Major Findings

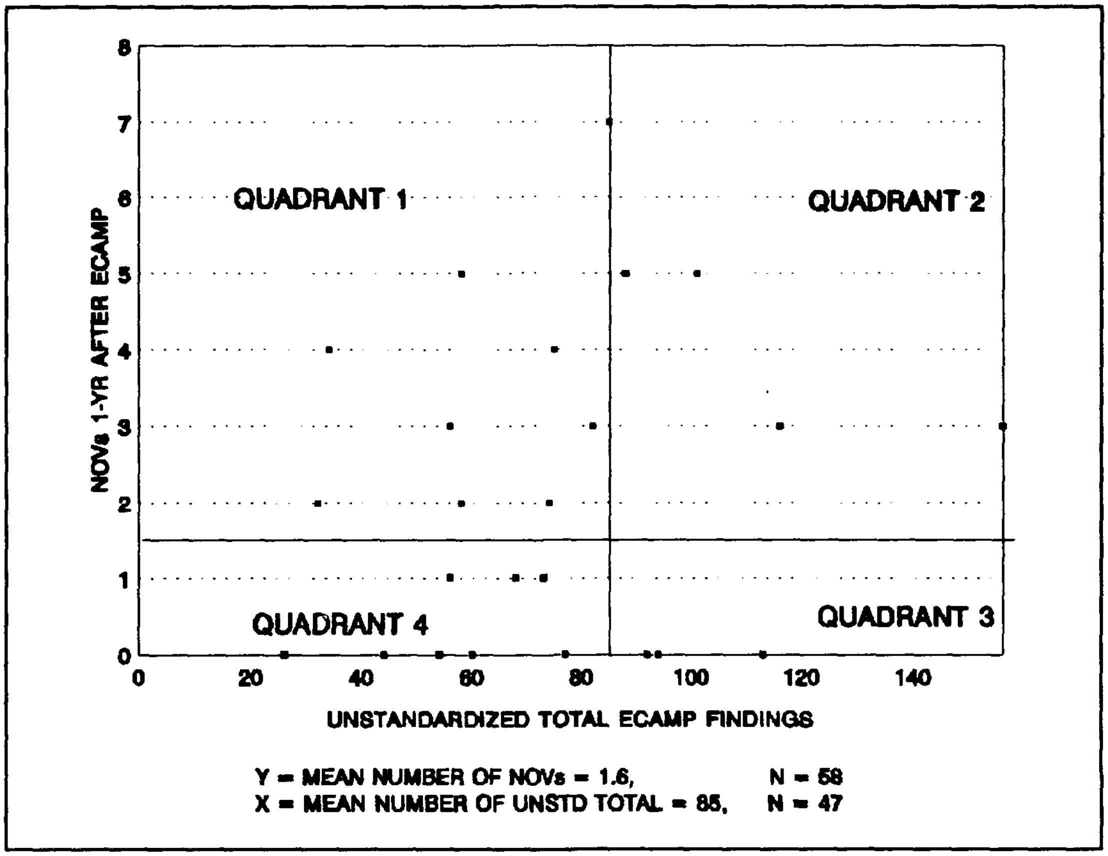

Figure 25. ECAMP Effectiveness Model, NOVs 1-Year After Versus Unstandardized Total Findings

Once again, several bases fall in different effectiveness quadrants when unstandardized findings are used as compared to standardized findings. Specifically, Figure 20 which uses standardized major findings shows four bases in different effectiveness quadrants than Figure 24 which uses unstandardized major findings. Similarly, four bases also fall in different quadrants when using standardized and unstandardized total findings as depicted in Figures 21 and 25. To better illustrate these differences, the data in Figures 22-25 is presented and analyzed by installation in Table 15.

TABLE 15

ECAMP EFFECTIVENESS MODEL DATA ANALYSIS FIGURES 22-25

BASE	QUAD. 1-YR PRIOR FIG 22	QUAD. 1-YR PRIOR FIG 23	QUAD. AFTER 1-YR FIG 24	QUAD. AFTER 1-YR FIG 25	EFFECT TREND	OVERALL RATINGS
AFMC-1	1	1	1	1	NO CHANGE	UNSAT/UNSAT
AFMC-3	4	4	4	4	NO CHANGE	EXCEL/EXCEL
AFMC-4	2	2	2	2	NO CHANGE	MARG/MARG
AFMC-5	3	4	2	1	DECREASE	SAT/MARG
AFMC-6	3	3	3	3	NO CHANGE	SAT/SAT
AFMC-7	3	3/4	2	1/2	DECREASE	SAT/MARG
AFMC-9	1	2	1	2	NO CHANGE	MARG/MARG
AFMC-10	2	2	2	2	NO CHANGE	MARG/MARG
AFMC-12	4	4	1	1	DECREASE	EXCEL/UNSAT
ACC-3	1	1	1	1	NO CHANGE	UNSAT/UNSAT
ACC-4	1	1	4	4	INCREASE	UNSAT/EXCEL
ACC-5	1	1	4	4	INCREASE	UNSAT/EXCEL
ACC-6	4	4	1	1	DECREASE	EXCEL/UNSAT
ACC-8	1	2	4	3	INCREASE	UNSAT/EXCEL

TABLE 15

ECAMP EFFECTIVENESS DATA ANALYSIS FIGURE 22-25

(1) BASE	QUAD. 1-YR PRIOR FIG 22	QUAD. 1-YR PRIOR FIG 23	QUAD. AFTER 1-YR FIG 24	QUAD. AFTER 1-YR FIG 25	EFFECT TREND	OVERALL RATINGS
ACC-10	4	4	4	4	NO CHANGE	EXCEL/EXCEL
ACC-18	4	4	4	4	NO CHANGE	EXCEL/EXCEL
ACC-24	4	4	4	4	NO CHANGE	EXCEL/EXCEL
ACC-28	4	4	1	1	DECREASE	EXCEL/UNSAT
ACC-31	3	3	3	3	NO CHANGE	SAT/SAT
ACC-32	4	4	4	4	NO CHANGE	EXCEL/EXCEL
ACC-33	3	3	2	2	DECREASE	SAT/MARG
AMC-1	1	1	1	1	NO CHANGE	UNSAT/UNSAT
AMC-9	4	4	1	1	DECREASE	EXCEL/UNSAT
AMC-10	1	1	4	4	INCREASE	UNSAT/EXCEL

Like the tabular analysis of ECAMP Effectiveness Model data using standardized ECAMP findings previously presented in Table 14, the analysis using unstandardized findings which is shown in Table 15 identifies the same eleven installations as having changes in ECAMP effectiveness.

This similarity exists because the effectiveness trends are controlled by the number of NOVs received by the respective installations over the two year period which was constant. However, the overall effectiveness ratings are influenced by the number of standardized or unstandardized ECAMP findings; thus, these ratings are variable. To aid in identifying the effects of standardizing ECAMP findings on overall effectiveness ratings, Table 16 lists base specific standardization factors and the overall effectiveness ratings for both analyses, indicates whether unstandardized findings resulted in better or worse ratings, and identifies the number of times (1-4) when the data points in Figures 18-21 fell in different or the same effectiveness quadrant as those in corresponding Figures 22-25.

TABLE 16

OVERALL ECAMP EFFECTIVENESS RATING COMPARISON

BASE	BEE STD FACTOR	OVERALL RATINGS STD FINDINGS	OVERALL RATINGS UNSTD FINDINGS	UNSTD RATING BETTER OR WORSE	FIGURE QUADRANT DIFFERENT/ SAME
AFMC-1	9	MARG/MARG	UNSAT/UNSAT	WORSE	4/0
AFMC-3	35	EXCEL/EXCEL	EXCEL/EXCEL	SAME	0/4
AFMC-4	51	UNSAT/UNSAT	MARG/MARG	BETTER	4/0
AFMC-5	16	EXCEL/UNSAT	SAT/MARG	WOR/BET	2/2
AFMC-6	43	EXCEL/EXCEL	SAT/SAT	WORSE	4/0
AFMC-7	32	EXCEL/UNSAT	SAT/MARG	WOR/BET	4/0
AFMC-9	47	UNSAT/UNSAT	MARG/MARG	BETTER	2/2
AFMC-10	24	UNSAT/UNSAT	MARG/MARG	BETTER	4/0
AFMC-12	51	EXCEL/UNSAT	EXCEL/UNSAT	SAME	0/4
ACC-3	12	UNSAT/UNSAT	UNSAT/UNSAT	SAME	0/4
ACC-4	12	UNSAT/EXCEL	UNSAT/EXCEL	SAME	0/4
ACC-5	5	MARG/EXCEL	UNSAT/EXCEL	WORSE	2/2
ACC-6	8	EXCEL/UNSAT	EXCEL/UNSAT	SAME	0/4
ACC-8	9	MARG/SAT	UNSAT/EXCEL	WOR/BET	2/2
ACC-10	5	EXCEL/EXCEL	EXCEL/EXCEL	SAME	0/4

TABLE 16

OVERALL ECAMP EFFECTIVENESS RATING COMPARISON

BASE	BEE STD FACTOR	OVERALL RATINGS STD FINDINGS	OVERALL RATINGS UNSTD FINDINGS	UNSTD RATING BETTER OR WORSE	FIGURE QUADRANT DIFFERENT/ SAME
ACC-18	6	SAT/SAT	EXCEL/EXCEL	BETTER	4/0
ACC-24	9	EXCEL/EXCEL	EXCEL/EXCEL	SAME	0/4
ACC-28	9	EXCEL/UNSAT	EXCEL/UNSAT	SAME	0/4
ACC-31	9	SAT/SAT	SAT/SAT	SAME	0/4
ACC-32	8	EXCEL/EXCEL	EXCEL/EXCEL	SAME	0/4
ACC-33	11	SAT/MARG	SAT/MARG	SAME	0/4
AMC-1	13	UNSAT/UNSAT	UNSAT/UNSAT	SAME	0/4
AMC-9	7	EXCEL/UNSAT	EXCEL/UNSAT	SAME	0/4
AMC-10	13	UNSAT/EXCEL	UNSAT/EXCEL	SAME	0/4

Table 16 shows that 32 of 96 data points were in different effectiveness quadrants when unstandardized ECAMP findings were used in the model as compared to standardized findings. These quadrant shifts resulted in 10 of 24 bases having different overall ECAMP effectiveness ratings. Of the ten installations with different overall ratings when unstandardized findings were used, four had better ratings, three had worse, and three had worse ratings using NOVs 1-year prior to the ECAMP evaluation and better ratings using NOVs from 1-year after the ECAMP (WOR/BET). Further inspection of Table 16 also reveals that seven of nine AFMC bases in the study had different overall effectiveness ratings when standardized findings were replaced with unstandardized findings. In contrast, only three of twelve and zero of three ACC and AMC study bases had different overall effectiveness ratings. In addition, the average value of the BEE standardization factor for the ten bases exhibiting different effectiveness ratings was 24.2 while the average standardization factor for the 14 bases with the same effectiveness rating was 14.42. Although inconclusive, these results suggest that the BEE standardization factor does account for the dissimilarities between large and small installations as expected and desired.

Overall, reanalyzing the NOV and ECAMP data for the same 24 bases using unstandardized findings demonstrated the flexibility of the proposed model and provided additional insight into the effects and potential benefits of standardizing ECAMP findings using BEE manpower authorizations. Ultimately, by using the proposed ECAMP Effectiveness Model, AF decision-makers can quickly and easily identify both installations with effective ECAMP programs and those bases where ECAMP programs may need more attention or resources to prevent future environmental problems and improve environmental compliance.

Summary. Theoretically, an effective ECAMP should be characterized by a negative correlation between NOVs and standardized ECAMP findings. Hypothetically, an effective ECAMP would be expected to progress through four distinct phases culminating in a perfectly effective auditing program where all potential compliance problems are identified, corrected and subsequently prevented.

Realistically, ECAMP effectiveness like environmental compliance is constantly changing due to confounding factors such as manpower shortages, changing environmental regulations, and varying levels of regulatory oversight. Thus, AF decision-makers need a quick, easy method of measuring relative ECAMP effectiveness so that scarce resources can be properly used to improve ECAMP effectiveness and prevent NOVs. By applying the proposed ECAMP Effectiveness Model to 24 bases with recent ECAMP evaluations and NOV data for both 1-year prior to and 1-year after the evaluation, this research demonstrated that the proposed model provides a quick and easy, visual indication of an installation's relative ECAMP effectiveness. Additional analyses using unstandardized ECAMP findings also demonstrated the flexibility of the proposed model and suggested that the BEE standardization factor does account for the dissimilarities between large and small installations as expected and desired. This information can then be used to assist AF decision-makers in identifying the installations that require resources to prevent future environmental problems and improve environmental compliance.

If approved and implemented by the AF, the proposed ECAMP Effectiveness Model could assist decision-makers in properly allocating and apportioning scarce resources among installations with competing environmental compliance requirements. Ultimately, using the proposed model to identify installations where resources are needed should improve ECAMP effectiveness thereby reducing AF NOVs and preventing fines and penalties pursuant to the Federal Facilities Compliance Act.

V. Conclusions and Recommendations

Overview

Chapter V reviews the research problem and objectives, summarizes and describes how the research results achieved the three research objectives, concludes that the ECAMP Effectiveness Model developed in this research provides a quick and easy, visual indication of an installation's relative ECAMP effectiveness, and recommends that AF and MAJCOM environmental leaders review the research results and consider using the proposed ECAMP Effectiveness Model as a metric to measure ECAMP effectiveness.

Problem Review

The DoD and AF are committed to being national leaders in protecting and enhancing the environment and achieving environmental compliance (38:v; 39:1). This commitment is exemplified by the AF Chief of Staff's goal of "no notices of violation" (36). However, the number of AF NOVs from 1990-1992 rose from 103 to 178 an increase of 73 percent (7; 13; 25). A July 1992 AF Inspector General Report also concluded that ECAMP findings were not being fully utilized and that "several commands were not effectively using external ECAMP reports to direct corrective actions or allocate resources" (4:6). To aid AF leaders in solving these problems, this research developed an ECAMP

Effectiveness Model that uses ECAMP findings and historical NOV data to assist decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance.

Results Summary

The proposed ECAMP Effectiveness Model was developed from the results of a research methodology that achieved the following research objectives.

1. Demonstrated that environmentally-related manpower determinants can be used to standardize ECAMP findings thereby enabling unbiased comparisons between dissimilar AF installations.

2. Developed a methodology that uses the standardized ECAMP findings to assist AF decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance.

3. Tested, evaluated, and revised the methodology for possible use throughout the AF.

Objective 1. To accomplish research objective 1, an extensive literature review was performed. This review concluded that using environmentally-related manpower determinants to standardize ECAMP findings for respective installations where they are being applied should allow unbiased comparisons of ECAMP findings from dissimilar installations using these same manpower determinants. Based on the results of the literature review, it was also concluded that the BEE manpower determinant should be the best standardizing factor since it has matured over time with the developing environmental legislation. This conclusion was also supported by subsequent manpower regression analyses which suggested that approximately 82 percent of the variations in environmental manpower authorizations (Y) could be explained by the variations in BEE manpower authorizations (X).

Although the validity of using BEE manpower authorizations could not be verified directly, seven of ten r^2 values were higher with standardized findings than with unstandardized findings in the expanded study. In addition, a comparative analysis of ECAMP Effectiveness Model results using both standardized and unstandardized ECAMP findings revealed that the average value of the BEE standardization factor for the ten bases exhibiting different overall effectiveness rating was 24.2 while the average standardization factor for the 14 bases with the same overall effectiveness ratings was 14.42. Although inconclusive, these results suggest that the BEE standardization factor does account for the dissimilarities between large and small installations as desired and expected. Moreover, weighting ECAMP findings before making resource allocation decisions using a standardization factor such as BEE manpower authorizations that should account for the installation specific environmental compliance requirements makes good managerial sense.

Objective 2. The first step in achieving research objective 2 was to test the theory that there should be a direct relationship between standardized ECAMP findings and environmental compliance by performing regression analyses using standardized ECAMP findings and historical NOV data from nine AFMC bases. Although the majority of the pilot study coefficients of determination were very low, the 0.79 and 0.84 r^2 values for five former AFLC installations were potentially significant and clearly justified expanding this study to installations in other commands.

In contrast to the pilot study, no significant relationships between NOVS and standardized or unstandardized ECAMP findings were identified in the expanded study. However, a detailed review of the expanded study data did result in a theoretical framework for the proposed ECAMP Effectiveness Model. The proposed model is patterned after the two-factor theory of leadership, and the model is based on the premise that fewer NOVs and fewer ECAMP findings are best.

Objective 3. Research objective 3 was achieved by testing the ECAMP Effectiveness Model both prospectively and retrospectively. This was accomplished by using the proposed model to analyze historical NOV data and both standardized and unstandardized ECAMP findings from 24 bases with ECAMP evaluations in 1991 or 1992 and with NOV data for both 1-year prior to and 1-year after the evaluation. The model results were then evaluated and compared using a tabular format based on the standard AF rating system of unsatisfactory, marginal, satisfactory, and excellent. Based on this testing and analysis, the proposed ECAMP Effectiveness Model should allow AF decision-makers to quickly and easily identify installations with effective ECAMP programs and those bases where ECAMP programs need more attention and/or resources.

Conclusions

Using the ECAMP Effectiveness Model developed in this research provides a quick and easy, visual indication of an installation's relative ECAMP effectiveness. The proposed model is extremely flexible; it can be easily adjusted to reflect changing AF or command goals or averages; it can be used both retrospectively and prospectively with either standardized and/or unstandardized ECAMP findings; and it uses manpower, NOV, and ECAMP report data that is readily available to decision-makers. If approved and implemented by the AF, the proposed ECAMP Effectiveness Model should assist decision-makers in properly allocating and apportioning scarce resources among installations with competing environmental compliance requirements. The proposed model provides decision-makers with an easy to use management tool that can help them to identify the installations that may need resources. Ultimately, using the ECAMP Effectiveness Model should improve ECAMP effectiveness thereby reducing AF NOVs and preventing fines and penalties pursuant to the Federal Facilities Compliance Act.

Recommendations

Air Force and MAJCOM environmental leaders should review the results of this research and adopt the proposed ECAMP Effectiveness Model as a metric to measure ECAMP effectiveness and assist AF decision-makers in allocating scarce resources to prevent future environmental problems and improve environmental compliance. Any questions, problems, or concerns with the proposed model should be documented and forwarded to the Air Force Institute of Technology's Department of Environmental Engineering and Management for possible model revision and/or follow-on research.

Appendix A: Manpower Regression Analysis Data

(1; 9; 14; 32; 33; 37)

BASE	AUTHORIZED BEE MANPOWER	AUTHORIZED ENV. MANPOWER
AFMC-1	9	9
AFMC-2	31	80
AFMC-3	44	47
AFMC-4	51	56
AFMC-5	16	19
AFMC-6	43	82
AFMC-7	32	90
AFMC-8	6	10
AFMC-9	47	77
AFMC-10	27	54
AFMC-11	5	2
AFMC-12	51	86
ACC-1	6	NOT AVAILABLE CLOSED
ACC-2	8	8
ACC-3	12	9
ACC-4	12	10
ACC-5	5	NOT AVAILABLE CLOSING
ACC-6	8	9

BASE	AUTHORIZED BEE MANPOWER	AUTHORIZED ENV. MANPOWER
ACC-7	8	6
ACC-8	9	15
ACC-9	7	7
ACC-10	5	7
ACC-11	6	6
ACC-12	6	NOT AVAILABLE CLOSING
ACC-13	NOT AVAILABLE CLOSED	NOT AVAILABLE CLOSED
ACC-14	10	9
ACC-15	NOT AVAILABLE CLOSED	NOT AVAILABLE CLOSED
ACC-16	7	9
ACC-17	7	14
ACC-18	6	NOT AVAILABLE CLOSING
ACC-19	6	NOT AVAILABLE CLOSING
ACC-20	6	6
ACC-21	7	8
ACC-22	10	9
ACC-23	12	10
ACC-24	9	6
ACC-25	10	9

BASE	AUTHORIZED BEE MANPOWER	AUTHORIZED ENV. MANPOWER
ACC-26	8	9
ACC-27	9	8
ACC-28	9	9
ACC-29	8	10
ACC-30	7	6
ACC-31	9	6
ACC-32	8	9
ACC-33	11	19
ACC-34	7	8
AMC-1	13	12-16
AMC-2	7	11-10
AMC-3	16	13-11
AMC-4	11	12-12
AMC-5	11	12-13
AMC-6	16	12-12
AMC-7	5	NOT AVAILABLE CLOSED
AMC-8	11	10-10
AMC-9	7	8-7
AMC-10	11	10-9

BASE	AUTHORIZED BEE MANPOWER	AUTHORIZED ENV. MANPOWER
AMC-11	9	15-12
AMC-12	15	14-17
AMC-13	12	11-12

Appendix B: AFMC Specific Manpower Regression Analysis Data

(37)

BASE	AUTHORIZED AFMC BEE MANPOWER APRIL 93	AUTHORIZED AFMC EM MANPOWER APRIL 92	AUTHORIZED AFMC EM MANPOWER APRIL 93	ACTUAL AFMC EM MANPOWER APRIL 93
AFMC-1	9	7	9	6
AFMC-2	31	80	80	50
AFMC-3	44	35	47	53
AFMC-4	51	43	56	44
AFMC-5	16	11	19	23
AFMC-6	43	65	82	83
AFMC-7	32	72	90	90
AFMC-8	6	11	10	8
AFMC-9	47	79	77	70
AFMC-10	27	51	54	26
AFMC-11	5	2	2	2
AFMC-12	51	60	86	84

Appendix C: Expanded Study ECAMP Finding and NOV Data

(7; 9; 13; 25; 29; 42)

(1) BASE/ ECAMP YEAR	(2) MAJOR ECAMP FINDINGS	(3) TOTAL ECAMP FINDINGS	(4) NOVs AFTER 1-YR	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
AFMC-1/92	47	82	3	9	5.22	9.11
AFMC-3/91	24	56	1	44	0.55	1.27
AFMC-4/91	68	101	5	51	1.33	1.98
AFMC-5/91	54	74	2	16	3.38	4.63
AFMC-6/91	55	113	0	43	1.28	2.63
AFMC-7/92	67	85	7	32	2.09	2.66
AFMC-9/92	44	88	5	47	0.94	1.87
AFMC-10/92	119	156	3	27	4.41	5.78
AFMC-12/92	48	75	4	51	0.94	1.47
ACC-1/90	19	34	5	6	3.17	5.67
ACC-3/91	42	58	5	12	3.50	4.83
ACC-4/91	43	73	1	12	3.58	6.08
ACC-5/91	25	44	0	5	5.00	8.80
ACC-6/91	32	56	3	8	4.00	7.00
ACC-8/92	48	94	0	9	5.33	10.44
ACC-10/91	22	54	0	5	4.40	10.80

(1) BASE/ ECAMP YEAR	(2) MAJOR ECAMP FINDINGS	(3) TOTAL ECAMP FINDINGS	(4) NOVs AFTER 1-YR	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
ACC-11/89	10	29	0	6	1.67	4.83
ACC-16/90	16	57	1	7	2.29	8.14
ACC-18/91	42	77	0	6	7.00	12.83
ACC-21/90	7	25	0	7	1.00	3.57
ACC-22/89	18	56	0	10	1.80	5.60
ACC-23/89	33	70	1	12	2.75	5.83
ACC-24/92	32	60	0	9	3.56	6.67
ACC-25/90	20	44	1	10	2.00	4.40
ACC-28/91	18	58	2	9	2.00	6.44
ACC-29/90	17	35	6	8	2.13	4.38
ACC-31/89	14	44	1	9	1.56	4.89
ACC-31/92	53	92	0	9	5.89	10.22
ACC-32/91	37	68	1	8	4.63	8.50
ACC-33/92	63	116	3	11	5.73	10.55
ACC-34/89	9	19	0	7	1.29	2.71

(1) BASE/ ECAMP YEAR	(2) MAJOR ECAMP FINDINGS	(3) TOTAL ECAMP FINDINGS	(4) NOVs AFTER 1-YR	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
AMC-1/91	17	34	4	13	1.31	2.62
AMC-9/92	12	32	2	7	1.71	4.57
AMC-10/91	13	26	0	11	1.18	2.36
AMC-13/90	20	40	1	12	1.67	3.33

Appendix D: ECAMP Effectiveness Model Historical NOV Data

(7; 13; 25)

(1) BASE	(2) ECAMP DATE	(3) NOVS 1-YR PRIOR	(4) NOVS AFTER 1-YR	(5) NOVs 1989	(6) NOVs 1990	(7) NOVs 1991	(8) NOVs 1992
AFMC-1	MAR 92	2	3	0	2	3	3
AFMC-2	SEP 92	0	N/A	0	0	0	3
AFMC-3	JUL 91	0	1	0	0	1	2
AFMC-4	OCT 91	2	5	2	3	2	4
AFMC-5	OCT 91	0	2	0	1	0	3
AFMC-6	DEC 91	0	0	1	2	0	0
AFMC-7	FEB 92	0	7	1	2	0	7
AFMC-8	JUL 92	1	N/A	1	0	2	0
AFMC-9	APR 92	2	5	0	0	2	5
AFMC-10	JAN 92	8	3	0	0	8	3
AFMC-11	MAY 92	0	0	0	1	0	0
AFMC-12	JAN 92	1	4	0	3	1	4
ACC-1	NOV 90	2	5	1	2	5	1
ACC-2	NONE	N/A	N/A	0	1	1	1
ACC-3	AUG 91	3	5	0	1	6	1
ACC-4	AUG 91	3	1	2	1	4	0

(1) BASE	(2) ECAMP DATE	(3) NOVs 1-YR PRIOR	(4) NOVs AFTER 1-YR	(5) 1989 NOVs	(6) 1990 NOVs	(7) 1991 NOVs	(8) 1992 NOVs
ACC-5	JUN 91	2	0	0	1	1	0
ACC-6	AUG 91	0	3	0	0	2	2
ACC-6	FEB 93	2	N/A	0	0	2	2
ACC-7	NOV 92	3	N/A	0	3	2	3
ACC-8	MAR 92	2	0	0	0	1	1
ACC-9	NOV 92	0	N/A	0	0	0	0
ACC-10	JUN 91	0	0	0	0	0	0
ACC-11	JUL 89	0	0	0	0	1	0
ACC-11	FEB 93	1	N/A	0	0	1	0
ACC-12	NONE	N/A	N/A	0	2	0	0
ACC-13	NONE	N/A	N/A	0	0	0	2
ACC-14	FEB 93	1	N/A	0	2	1	1
ACC-15	NONE	N/A	N/A	0	0	2	1
ACC-16	APR 90	1	1	1	1	0	2
ACC-16	JAN 93	2	N/A	1	1	0	2

(1) BASE	(2) ECAMP DATE	(3) NOVs 1-YR PRIOR	(4) NOVs AFTER 1-YR	(5) 1989 NOVs	(6) 1990 NOVs	(7) 1991 NOVs	(8) 1992 NOVs
ACC-17	OCT 92	2	1	0	0	2	2
ACC-18	OCT 91	1	0	1	0	1	0
ACC-19	JUN 92	1	N/A	0	0	1	4
ACC-20	OCT 92	3	N/A	0	2	0	3
ACC-21	NOV 90	0	0	0	0	0	3
ACC-22	DEC 89	0	0	0	0	1	0
ACC-22	JUL 92	1	N/A	0	0	1	0
ACC-23	AUG 89	0	1	0	1	0	2
ACC-23	DEC 92	2	N/A	0	1	0	2
ACC-24	FEB 92	1	0	0	0	1	0
ACC-25	JUN 90	0	1	0	0	1	1
ACC-25	OCT 92	1	N/A	0	0	1	1
ACC-26	AUG 92	1	N/A	1	0	1	2
ACC-27	JAN 93	0	N/A	0	0	0	0

(1) BASE	(2) ECAMP DATE	(3) NOVs 1-YR PRIOR	(4) NOVs AFTER 1-YR	(5) 1989 NOVs	(6) 1990 NOVs	(7) 1991 NOVs	(8) 1992 NOVs
ACC-28	MAR 91	1	2	2	1	2	0
ACC-29	AUG 90	2	6	2	4	7	3
ACC-29	JUL 92	6	N/A	2	4	7	3
ACC-30	MAR 93	2	N/A	3	1	1	2
ACC-31	JUN 89	2	1	1	1	1	0
ACC-31	MAR 92	1	0	1	1	1	0
ACC-32	DEC 91	1	1	1	1	1	1
ACC-33	FEB 92	1	3	1	1	1	3
ACC-34	AUG 89	0	0	0	0	0	0
ACC-34	FEB 93	0	N/A	0	0	0	0
AMC-1	MAR 91	2	4	2	3	3	3
AMC-2	NONE	N/A	N/A	0	0	1	0
AMC-3	NONE	N/A	N/A	0	5	5	6
AMC-4	SEP 92	1	N/A	0	1	0	1

(1) BASE	(2) ECAMP DATE	(3) NOVs 1-YR PRIOR	(4) NOVs AFTER 1-YR	(5) NOVs 1989	(6) NOVs 1990	(7) NOVs 1991	(8) NOVs 1992
AMC-5	NONE	N/A	N/A	0	1	0	1
AMC-6	NONE	N/A	N/A	0	2	1	1
AMC-7	SEP 92	2	N/A	0	0	2	2
AMC-8	NONE	N/A	N/A	0	1	0	3
AMC-9	APR 92	1	2	0	0	1	2
AMC-10	SEP 91	2	0	0	1	2	0
AMC-11	AUG 92	4	N/A	0	3	8	0
AMC-12	NONE	N/A	N/A	0	1	1	3
AMC-13	DEC 90	0	1	0	0	1	1

Appendix E: Effectiveness Model Historical ECAMP Findings

(9; 29; 42)

(1) BASE	(2) ECAMP DATE	(3) MAJOR ECAMP FINDINGS	(4) TOTAL ECAMP FINDINGS	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
AFMC-1	MAR 92	47	82	9	5.22	9.11
AFMC-2	SEP 92	198	253	31	6.39	8.16
AFMC-3	JUL 91	24	56	44	0.55	1.27
AFMC-4	OCT 91	68	101	51	1.33	1.98
AFMC-5	OCT 91	54	74	16	3.38	4.63
AFMC-6	DEC 91	55	113	43	1.28	2.63
AFMC-7	FEB 92	67	85	32	2.09	2.66
AFMC-8	JUL 92	62	100	6	10.33	16.67
AFMC-9	APR 92	44	88	47	0.94	1.87
AFMC-10	JAN 92	119	156	27	4.41	5.78
AFMC-11	MAY 92	29	71	5	5.80	14.20
AFMC-12	JAN 92	48	75	51	0.94	1.47
ACC-1	NOV 90	19	34	6	3.17	5.67
ACC-2	NOT AVAIL	N/A	N/A	N/A	N/A??	N/A??
ACC-3	AUG 91	42	58	12	3.50	4.83
ACC-4	AUG 91	43	73	12	3.58	6.08

(1) BASE	(2) ECAMP DATE	(3) MAJOR ECAMP FINDINGS	(4) TOTAL ECAMP FINDINGS	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
ACC-5	JUN 91	25	44	5	5.00	8.80
ACC-6	AUG 91	32	56	8	4.00	7.00
ACC-6	FEB 93	69	159	8	8.63	19.88
ACC-7	NOV 92	79	161	8	9.88	20.13
ACC-8	MAR 92	48	94	9	5.33	10.44
ACC-9	NOV 92	76	114	7	10.86	16.29
ACC-10	JUN 91	22	54	5	4.40	10.80
ACC-11	JUL 89	10	29	6	1.67	4.83
ACC-11	FEB 93	55	105	6	9.17	17.50
ACC-12	NOT AVAIL	N/A	N/A	N/A	N/A	N/A
ACC-13	NOT AVAIL	N/A	N/A	N/A	N/A	N/A
ACC-14	FEB 93	51	103	10	5.10	10.30
ACC-15	NO. AVAIL	N/A	N/A	N/A	N/A	N/A
ACC-16	APR 90	16	57	7	2.29	8.14
ACC-16	JAN 93	49	85	7	7.00	12.14

(1) BASE	(2) ECAMP DATE	(3) MAJOR ECAMP FINDINGS	(4) TOTAL ECAMP FINDINGS	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
ACC-17	OCT 92	59	104	7	8.43	14.86
ACC-18	OCT 91	42	77	6	7.00	12.83
ACC-19	JUN 92	50	81	6	8.33	13.50
ACC-20	OCT 92	46	74	6	7.67	12.33
ACC-21	NOV 90	7	25	7	1.00	3.57
ACC-22	DEC 89	18	56	10	1.80	5.60
ACC-22	JUL 92	40	81	10	4.00	8.10
ACC-23	AUG 89	33	70	12	2.75	5.83
ACC-23	DEC 92	59	102	12	4.92	8.50
ACC-24	FEB 92	32	60	9	3.56	6.67
ACC-25	JUN 90	20	44	10	2.00	4.40
ACC-25	OCT 92	46	91	10	4.60	9.10
ACC-26	AUG 92	42	72	8	5.25	9.00
ACC-27	JAN 93	53	75	9	5.89	8.33

(1) BASE	(2) ECAMP DATE	(3) MAJOR ECAMP FINDINGS	(4) TOTAL ECAMP FINDINGS	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
ACC-28	MAR 91	18	58	9	2.00	6.44
ACC-29	AUG 90	17	35	8	2.13	4.38
ACC-29	JUL 92	40	69	8	5.00	8.63
ACC-30	MAR 93	69	134	7	9.86	19.14
ACC-31	JUN 89	14	44	9	1.56	4.89
ACC-31	MAR 92	53	92	9	5.89	10.22
ACC-32	DEC 91	37	68	8	4.63	8.50
ACC-33	FEB 92	63	116	11	5.73	10.55
ACC-34	AUG 89	9	19	7	1.29	2.71
ACC-34	FEB 93	53	82	7	7.57	11.71
AMC-1	MAR 91	17	34	13	1.31	2.62
AMC-2	NOT AVAIL	N/A	N/A	N/A	N/A	N/A
AMC-3	NOT AVAIL	N/A	N/A	N/A	N/A	N/A
AMC-4	SEP 92	17	38	11	1.55	3.45

(1) BASE	(2) ECAMP DATE	(3) MAJOR ECAMP FINDINGS	(4) TOTAL ECAMP FINDINGS	(5) BEE STD FACTOR	(6) BEE STD MAJOR	(7) BEE STD TOTAL
AMC-5	NOT AVAIL	N/A	N/A	N/A	N/A??	N/A??
AMC-6	NOT AVAIL	N/A	N/A	N/A	N/A??	N/A??
AMC-7	SEP 92	14	32	5	2.80	6.40
AMC-8	NOT AVAIL	N/A	N/A	N/A	N/A??	N/A??
AMC-9	APR 92	12	32	7	1.71	4.57
AMC-10	SEP 91	13	26	11	1.18	2.36
AMC-11	AUG 92	26	50	9	2.89	5.56
AMC-12	NOT AVAIL	N/A	N/A	N/A	N/A??	N/A??
AMC-13	DEC 90	20	40	12	1.67	3.33

Appendix F: Effectiveness Model Data Figures 18-21

(1) BASE	(2) ECAMP DATE	(3) NOVS 1-YR PRIOR	(4) NOVS AFTER 1-YR	(5) STD MAJOR FINDINGS	(6) STD TOTAL FINDINGS
AFMC-1	MAR 92	2	3	5.22	9.11
AFMC-3	JUL 91	0	1	0.55	1.27
AFMC-4	OCT 91	2	5	1.33	1.98
AFMC-5	OCT 91	0	2	3.38	4.63
AFMC-6	DEC 91	0	0	1.28	2.63
AFMC-7	FEB 92	0	7	2.09	2.66
AFMC-9	APR 92	2	5	0.94	1.87
AFMC-10	JAN 92	8	3	4.41	5.77
AFMC-12	JAN 92	1	4	0.94	1.47
ACC-3	AUG 91	3	5	3.5	4.83
ACC-4	AUG 91	3	1	3.58	6.08
ACC-5	JUN 91	2	0	5	8.8
ACC-6	AUG 91	0	3	4	7
ACC-8	MAR 92	2	0	5.33	10.44
ACC-10	JUN 91	0	0	4.4	10.8
ACC-18	OCT 91	1	0	7	12.83

(1) BASE	(2) ECAMP DATE	(3) NOVs 1-YR PRIOR	(4) NOVs AFTER 1-YR	(5) STD MAJOR FINDINGS	(6) STD TOTAL FINDINGS
ACC-24	FEB 92	1	0	3.56	6.67
ACC-28	MAR 91	1	2	2	6.44
ACC-31	MAR 92	1	0	5.89	10.22
ACC-32	DEC 91	1	1	4.63	8.5
ACC-33	FEB 92	1	3	5.73	10.55
AMC-1	MAR 91	2	4	1.31	2.62
AMC-9	APR 92	1	2	1.71	4.57
AMC-10	SEP 91	2	0	1.18	2.36

Appendix G: Effectiveness Model Data Figures 22-25

(1) BASE	(2) ECAMP DATE	(3) NOVS 1-YR PRIOR	(4) NOVS AFTER 1-YR	(5) UNSTD MAJOR FINDINGS	(6) UNSTD TOTAL FINDINGS
AFMC-1	MAR 92	2	3	47	82
AFMC-3	JUL 91	0	1	24	56
AFMC-4	OCT 91	2	5	68	101
AFMC-5	OCT 91	0	2	54	74
AFMC-6	DEC 91	0	0	55	113
AFMC-7	FEB 92	0	7	67	85
AFMC-9	APR 92	2	5	44	88
AFMC-10	JAN 92	8	3	119	156
AFMC-12	JAN 92	1	4	48	75
ACC-3	AUG 91	3	5	42	58
ACC-4	AUG 91	3	1	43	73
ACC-5	JUN 91	2	0	25	44
ACC-6	AUG 91	0	3	32	56
ACC-8	MAR 92	2	0	48	94
ACC-10	JUN 91	0	0	22	54
ACC-18	OCT 91	1	0	42	77

(1) BASE	(2) ECAMP DATE	(3) NOVs 1-YR PRIOR	(4) NOVs AFTER 1-YR	(5) UNSTD MAJOR FINDINGS	(6) UNSTD TOTAL FINDINGS
ACC-24	FEB 92	1	0	32	60
ACC-28	MAR 91	1	2	18	58
ACC-31	MAR 92	1	0	53	92
ACC-32	DEC 91	1	1	37	68
ACC-33	FEB 92	1	3	63	116
AMC-1	MAR 91	2	4	17	34
AMC-9	APR 92	1	2	12	32
AMC-10	SEP 91	2	0	13	26

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Vita

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13. ABSTRACT *(Maximum 200 words)*

The Department of Defense (DoD) and the Air Force (AF) are committed to being national leaders in protecting and enhancing the environment and achieving environmental compliance. This commitment is exemplified by the Air Force Chief of Staff's goal of "no notices of violation (NOVs)." However, the number of AF NOVs from 1990-1992 rose from 103 to 178 an increase of 73 percent. A July 1992 AF Inspector General Report also concluded that Environmental Compliance Assessment and Management Program (ECAMP) findings were not being effectively utilized by the Major Commands (MAJCOM).

To aid AF leaders in solving these problems, and protecting and enhancing the environment, this research developed a methodology to standardize and use ECAMP findings along with historical NOV data, to assist decision-makers in identifying the installations that require resource allocation to prevent future environmental problems and improve environmental compliance. The ECAMP Effectiveness Model developed in this research provides managers with a quick and easy, visual indication of an installation's relative ECAMP effectiveness. Based on these research findings, it was recommended to that Air Staff and MAJCOM environmental leaders review the research results and adopt the proposed model as a metric to measure ECAMP effectiveness.

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